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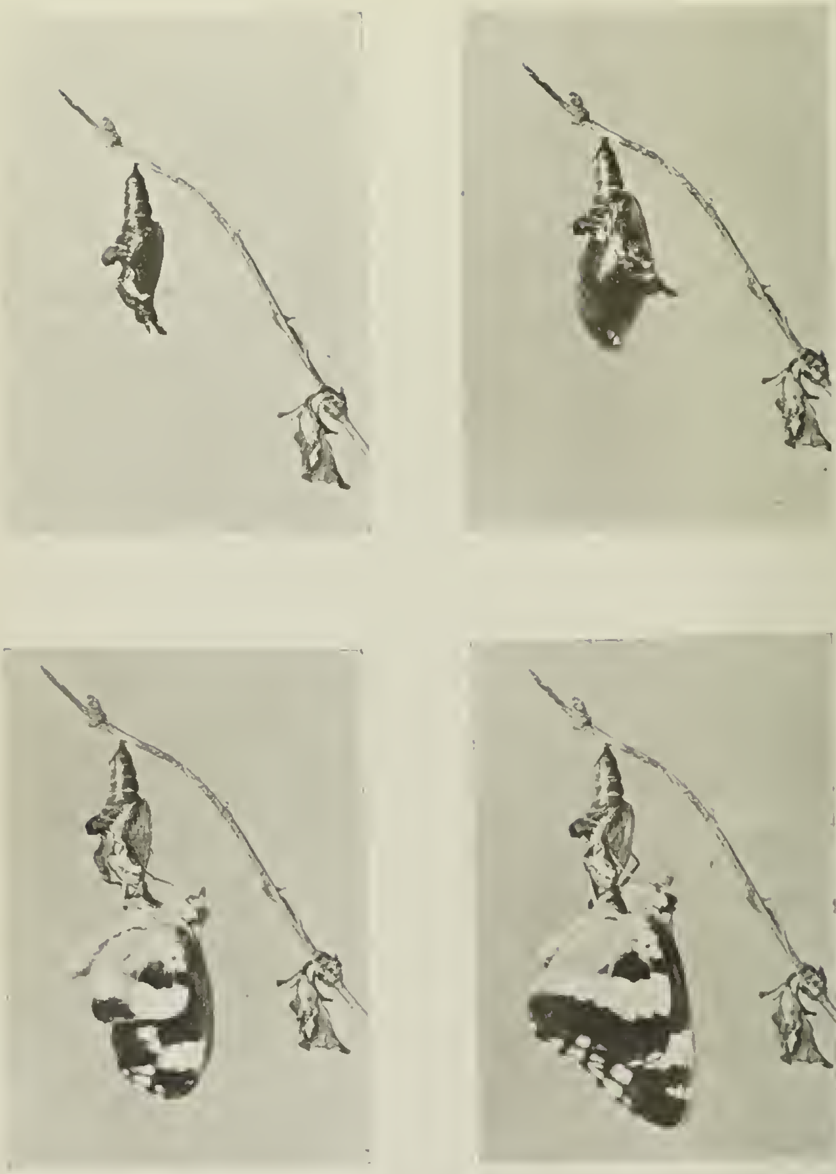
SOME NATURE BIOGRAPHIES

BY THE SAME AUTHOR

MINUTE MARVELS OF NATURE

PEEPS INTO NATURE'S WAY



THE WHITE ADMIRAL BUTTERFLY EMERGING FROM ITS CHRYSALIS.

The process of development from the chrysalis to the butterfly stage is but the work of a few seconds.

[*Frontispiece.*

SOME NATURE BIOGRAPHIES

PLANT — INSECT — MARINE — MINERAL. BY JOHN J. WARD

WITH UPWARDS OF 200 ILLUSTRATIONS REPRODUCED FROM PHOTOGRAPHS AND PHOTO-MICROGRAPHS TAKEN BY THE AUTHOR

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PREFACE

THE chapters which form this volume were originally published as articles in the *Strand Magazine*, *Pall Mall Magazine*, *Sunday Strand*, *Grand Magazine*, *The English Illustrated Magazine*, *The County Gentleman*, *The Girl's Realm*, and *The Animal World*. As they have appeared thus from time to time, they have brought me many letters of generous appreciation from readers in all parts of the world, coupled so often with the suggestion that I should re-publish them in book form, that I now offer this selection to the public for a possible wider reading.

I have largely revised the letterpress of the several chapters since their periodical publication, in some cases adding considerably to the matter. As regards the illustrations, also, the Publisher has spared no expense. Their number has been considerably added to, and in all cases entirely new blocks have been made. Chapters VIII. and XIV., which originally appeared in the *Grand Magazine* without illustrations, are now fully illustrated.

The several life histories contained in this volume are largely the outcome of personal observations of Nature, as my camera work will prove; and I think I may justly claim to show some unique examples of insect photography, especially in such photographs as those reproduced in Figures 9–16, 45–48, 67, 69–72, 91–94, and 183–186, where the objects are depicted of natural size. It should be remembered, too, that the developments shown in these illustrations are the work of a few seconds only, and that the photographer, in most cases, has only the one opportunity; if a single link in the rapid

succession of events is missed, the whole set of pictures becomes a failure—and that, too, often after twelve months of careful observation and waiting. I do not need to say that the pictures referred to are all examples of successful accomplishment. I have had failures, many of them, but they do not appear in this book.

On the side of plant life, Chapter II. contains a series of pictures illustrating an original idea, which, in working out photographically, is not so simple as at first it may seem to be. And, again, "The Story of a Landscape during Twelve Months" is a conception that I do not think has ever before been depicted photographically.

As I have already stated, the volume is largely the outcome of observations that I have personally made from time to time upon the actual organisms with which I deal; but I scarcely need say that, nowadays, any writer on scientific subjects must be more or less dependent upon the researches of others. His own study and observation are imposed upon the garnered knowledge of his time, and, therefore, should any readers discover (as they sometimes do) that the labours of Darwin, Kerner, Lubbock (Lord Avebury), Wallace, Müller, Agassiz, and similar standard authorities have incidentally served me in good stead, I hope this frank acknowledgment of my obvious indebtedness will avoid undeserved censure. Wherever it has seemed important I have given my authority in the text.

Finally, I offer the volume to all who love Nature and the countryside, and if it should render service in making clearer to its readers some of Nature's wonderful methods of working, and thereby make their country rambles more enjoyable and instructive, the volume will have accomplished its aim and its author will be gratified.

J. J. W.

Rusinurbe House,
Coventry,
September, 1907.

CONTENTS

LIST OF ILLUSTRATIONS

SOME NATURE BIOGRAPHIES

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CHAPTER I

The Life Story of the White Admiral Butterfly (*Limenitis sibylla*)

The Mating

OUR first glimpse of a White Admiral butterfly on the wing is almost startling. We must, however, make our way south and to secluded woods if we wished to see this handsome insect flying; since, in the British Isles, its habitat is almost entirely confined to the southern counties. We may perchance be sauntering through a sunlit glade of the New Forest, or along a woodland path in Surrey, Sussex, or Devonshire, or, it may be, in the Isle of Wight, when, like a flash of light, two of these lovely insects suddenly come into view. Although their flight is bold, swift, and continuous, yet they stand out most conspicuously in the sunlight as they carry on their giddy flirtation, for the contrasting velvety black and white of the upper surfaces of their wings cannot be other than showy in the bright sunlight.

In this way we have caught a glimpse of these charming butterflies, and long to see them again while we continue our ramble in the wood. We come upon many and various kinds of butterflies, but nearly all seem commonplace after witnessing the sportive flight and striking hues of the White Admiral. Of course, if we should fortunately happen to catch a glimpse of

the male insect of the larger and rarer Purple Emperor butterfly (which frequent almost the same localities) flashing his purple hues in the sunlight, we might for the moment forget the insects that had just charmed us so much. But the Purple Emperor when flying loves to sail above the summits of the tall oak trees, and is rarely seen low down, unless it is seeking carrion, on which—incongruous as it may seem—this gorgeously coloured insect delights to feast.

No Purple Emperor has appeared to view, however, and we are still looking in vain for White Admirals even when we reach the end of the glade; for these insects are not usually seen in large numbers even in their favourite haunts. But it may be interesting to state that, during recent years, this species of butterfly has apparently become somewhat abundant, and its extinction, predicted so confidently by some authorities, will, it is hoped, now be deferred indefinitely.

The Egg

Just as we have reached the end of the glade, and, therefore, almost given up hopes of seeing another Admiral, right on the very border a butterfly appears, hovering against a honeysuckle bush. Yes, sure enough, it is an Admiral. There are the conspicuous white bands and spots on the velvety black ground of the surface of the wings. But surely something is amiss. The flight of this butterfly is altogether different from that of the previous examples we have seen. It is irregularly fluttering from leaf to leaf of the honeysuckle, apparently carefully examining each, much as an insectivorous bird might do when seeking a meal. And every now and again it alights upon a leaf or disappears amidst the foliage for a moment or two, shortly reappearing to perform similar movements amongst other leaves, and so on over and over again, but always amidst honeysuckle leaves. After some minutes spent in this occupation the butterfly flies along the glade, eventually disappearing amongst the trees.

Before we leave the wood we must carefully examine those

leaves around which the insect has been moving, for they have a story to tell. We have, fortunately, alighted upon the very beginning of things in the various life-stages of this charming butterfly.

Truth to tell, the insect we have just seen so busily and seriously occupied was once as frivolous and coquettish as the one we saw pursued in the love-chase. But no longer has she the time or inclination for winged dalliance up and down the glades; she has much more important affairs on hand. She is looking out suitable sites on which to deposit her tiny eggs. This accounts for the careful manner in which she was scrutinizing the leaves when we first saw her. Although she cannot eat green food herself, yet, by some mysterious instinct, she knows quite well that the baby caterpillars which will eventually hatch from her eggs will need honeysuckle leaves to feed upon.

Fig. 1.—A magnified view of the butterfly's egg, which is really only about half the size of a pin's head.

So we carefully search amongst the leaves, and there, without a doubt, on quite a number of them we find a single egg deposited. These eggs are about half the size of a pin's head, of a pearly hue, and are generally placed on the edge of the upper surface of the leaf, often near the apex. But let me show you one of them through my pocket lens, and then you will see what a really wonderful little object it is (Fig. 1). It is sculptured with hexagonal pits, and studded over with sharp spines, which latter probably serve to protect it from

the attacks of some of its parasitic foes. Let us now make a note of the date when these wonderful eggs were deposited (July 16), for we have more to learn about them.

The Caterpillar

Twelve days later from one of these minute eggs emerges a tiny caterpillar; and soon from the other eggs further little caterpillars appear. The baby caterpillar slowly toddles along

Fig. 2.—The tiny caterpillar's method of feeding is curious, for the larva carefully consumes all the green leaf from the central vein, working from the tip downwards.

the edge of the leaf towards the apex, never ceasing until the very tip of the leaf is reached. At first it is so very small, and eats so little, that it feeds for several hours on the tip of the leaf without causing any apparent destruction. Two or three days later, though, while the caterpillar is still not very obvious, its ravages become more apparent, for its curious method of

feeding betrays it—at least to the observant entomologist. Look at illustration Fig. 2, and observe how from the tip of the midrib the leaf is being slowly consumed. The caterpillar does not eat the leaf indiscriminately, but steadily devours it from above downwards, and then, what is more curious still, when it has for the time finished feeding and desires to rest, it ascends to the very tip of the cleaned midrib and there it

Fig. 3.—In September the caterpillars spin silken threads about the bases of the leaf-stalks to prevent the leaves falling in the autumn.

peacefully sleeps, descending to its dining-room area below when it again needs refreshment. The skin of the young caterpillar is very rough, and, probably by resting in this elevated position on the bare vein of the leaf, its superficial resemblance to a tiny portion of the leaf still adhering to the vein makes it less likely to be seen by its enemies than if it rested in the feeding area, where insectivorous foes would be more disposed to glance. The process of consuming the leaf is a slow one, for the caterpillar at this stage does not eat

largely, but spends much time at rest. Perhaps by the end of August it may, or may not, have started on a second leaf, and, in fact, at that period seems little desirous of feeding at all. In September it makes its way to the base of the leaf, and commences to spin some silken threads about the stalk where it joins the stem. Marvellous though it may seem, yet this tiny and unreasoning larva is preparing for winter. Some

Fig. 4.—Throughout the winter months the tiny caterpillars rest hidden in the shrunken portions of the leaves they so carefully attached with silken cables to the branches.

intuitive instinct has warned it that some night, or maybe early morning, in the near future there may come a nipping frost, after which those honeysuckle leaves, almost ready to separate from their parent stems, will fall suddenly and without warning. So the young caterpillar takes time by the forelock and guards against disaster, lest it should fall also when the leaves drop.

In illustration Fig. 3 we see the tiny caterpillar carefully

spinning silken threads round the base of the leaf stalk, in readiness for the autumn "fall." Then the edges of the remaining uneaten portion of the leaf are stitched together with other threads, the caterpillar snugly ensconcing itself in the hollow at the base of the leaf. In due course, when the leaf should naturally drop, although it separates from the main stem in the usual way, yet the silken cables prevent it

FIG. 5.—In early May the caterpillars are about half grown.

falling. Thus it remains hanging to the stem, and dries and shrivels around the young larva (Fig. 4), looking exactly like many other bits of tattered leaves round about it, which for various reasons remain attached to the stems, but giving no indication of its living burden within.

In its leafy covering the tiny caterpillar sleeps away the slowly passing winter months, disguised from the few of its enemies that are abroad, and protected from wintry blasts, frosts, and rain alike. From six to seven of the twelve

months of its life it spends in this long rest, and if it did not feed on honeysuckle leaves it might have to wait longer; but honeysuckle leaves are amongst the earliest that push aside the protective winter scales that surround their buds.

Some day in April the warm sun wakes up the young larva from its long sleep, and it works its way through some weak spot of its winter domicile. To its great delight, when it gets outside, it finds abundant young and juicy honeysuckle leaves

FIG. 6.—By the middle of May the caterpillars are full grown.

round about it. Then it discovers how really hungry it is, and begins forthwith to eat ravenously. It may be due to this gnawing hunger that its earlier habit of daintily cleaning the midrib of the leaf is quite lost, for it now consumes any portion of the leaves indiscriminately. As a consequence of its ravenous appetite it begins to grow rapidly, so that, from time to time, it gets too large for its skin, which it has to moult, a new skin with ample room for further growth developing beneath the one about to be cast off. In illustration

Fig. 5 we see two larvæ as they appear on May 4. We notice, too, that they are developing a spiny appearance, but this feature becomes more apparent when they are full grown.

By the middle of May we find the larvæ full fed, and in Fig. 6 are shown some caterpillars as they appear at this stage (May 18). They are of a bright green colour, shading darker along the upper surface and lighter towards the sides,

FIG. 7.—When the larva is full-fed it spins a little silken pad to a branch and suspends itself to this by its tail end.

where the light area terminates in a white band. Long and short, dark brown, branched spines also decorate their dorsal parts. Perhaps these prickly spines make the larva unpalatable to some of their enemies.

We have seen that, counting from the time the eggs were deposited, it requires about ten months to develop the full-grown caterpillar. Now, as the complete life of the insect occupies not more, and sometimes less, than twelve months, it follows that some considerable development has to be made

during the short remaining period of time. This development we have now to record.

The Pupa or Chrysalis

So soon as the caterpillar has assimilated sufficient green leaf material to carry it through the next stage in its development its appetite declines. Then it selects a comfortable spot

Fig. 8.—After hanging as shown in Fig. 7 or two or three days, it moults its last caterpillar skin (which can be seen shrunken up at its tail end) and becomes a chrysalis.

on a stem or on the vein of a leaf, and there it proceeds to spin a little silken pad. When this pad is completed the larva suspends itself to it by its tail claspers, and so hangs head downwards, in a slightly curved position (Fig. 7). In this attitude the larva remains motionless for from two to three days. Then it seems to suddenly wake up, and a wriggling movement begins. While we watch it we see that something is happening to the caterpillar. It is swinging from side to

side, and as it swings we observe that the caterpillar's skin has broken away near its head, and with each swing the skin is slowly sliding towards its tail end. And, lo! in the course of a minute or two we have enacted before us a complete transformation, for the caterpillar becomes a curious two-horned pupa or chrysalis. In illustration Fig. 8 the chrysalis is seen

Fig. 9.—At the beginning of June the chrysalis assumes a greasy appearance, and the dark colour of the butterfly, now almost ready to emerge, shows through the semi-transparent shell of the chrysalis.

making its last swing, with the shrunken caterpillar skin at its tail end.

When the moulted skin is almost free, a very dexterous feat has to be performed by the pupa, for it has to withdraw the extremity of its abdomen from its cast-off skin, and apparently with nothing to hold to in the meanwhile. However, this gymnastic manœuvre is quickly and successfully performed, the pupa adhering in some peculiar way to some other parts of its larval skin while it disconnects its latter

portions, and then reconnects them directly with the silken pad, a number of tiny hooks being provided on the tip of the abdomen for this purpose. Then the last caterpillar skin falls away, and we have no longer a caterpillar, for the dormant pupa or chrysalis is born.

The Butterfly

At first the chrysalis is very much the same colour as the larva, but the area covering the embryo wings slowly darkens

Fig. 10.—Then, the opportune moment arrived, the chrysalis bulges at its broader end, and then bursts. Instantly through the opening appears the head and fore-parts of the butterfly.

in hue, eventually assuming a deep olive-green shade. The other parts are of a pale green shaded with brown, the whole being flecked with streaks and spots of bright gold.

From the time when the pupa under observation formed (May 20) it hung for sixteen days (until June 4). Then it became obvious that some further development was about to

take place. The shell of the chrysalis assumed a greasy appearance, and the pupa darkened very much in colour; the latter being due to the dark-coloured wings of the insect within, now almost ready to emerge as a fully developed butterfly (Fig. 9).

Our purpose now must be to endeavour to witness the birth of the butterfly, and in this we have set ourselves no light task. The emergence from the chrysalis and unfolding

FIG. 11.—It clings to the empty chrysalis by its legs while it shakes the folds from its wings.

of the wings of the butterfly are but the work of a few seconds; but, as we have no means of ascertaining the exact moment (of the next twelve or twenty-four hours, perhaps) when the insect will appear, there is no alternative if we are determined to see it enter its new sphere of life as a butterfly; we must watch and wait patiently.

About 10 a.m. the following day (June 5) a ray of sunlight happened to fall directly in the path of the chrysalis

under observation. Immediately there was a response. The pupa suddenly jerked as if startled by the light. This was the beginning of great things—that wandering ray of light was evidently Nature's signal to the hidden butterfly within, informing it that *then* was the opportune moment for it to come forth.

Instantly the chrysalis began to bulge at its broader end. Then the enveloping shell burst open, and the head of the

Fig. 12.—The wings have unfolded, but are soft and limp.

butterfly quickly appeared through the opening (Fig. 10), the insect then gently slipping out in this position head downwards, withdrawing as it came its closely folded wings, its pressed-back antennæ, or "feelers," and finally its abdomen and legs. Just as one expected to see it fall to the ground its wings suddenly swelled out, and in an instant the butterfly was free from its chrysalis (which, owing to its elasticity, immediately closed up again), and was clinging to the empty shell by

its legs, its wings while in this position rapidly extending their folds (Fig. 11). A little more than a minute later they had reached their full length (Fig. 12); and now, everything having passed off successfully, there was the newly-born butterfly resting on the empty chrysalis—the last of its skins that it would have to moult.

Our butterfly, though, was far from being perfect yet. Its wings were limp and wet, and the slightest puff of wind blew

FIG. 13.—The wings dry, and then the butterfly bears a trim and neat appearance.

them like so much wet rag. But slowly the butterfly lost its flimsy and draggled aspect, and at the end of an hour it bore a very trim and neat appearance (Fig. 13). Soon after this it gave its wings a sharp flutter, and then slowly climbed its empty chrysalis on to the stem (Fig. 14), revealing as it went the lovely mahogany-browns and blue-grey hues of the undersides of its wings. Having finally reached the topmost point of the branch, the first glimpse was obtained of the soft, rich,

velvety effect of their upper surface. At the very tip of the branch it almost lost its foothold, and to balance itself it opened wide its glorious wings (Fig. 15) as instinct taught it, for it had yet to learn what wonderful feats it could perform with those splendidly and marvellously constructed organs.

There, then, it poised itself, its rich and lovely glossy black and white wings sheening delightfully as they moved, while the insect balanced itself. The colours of the butterflies we have

FIG. 14.—It gets ready to use its velvety black and white wings.

seen flying in the woodland glade charmed us, it is true, but here we had the richness and purity of the newly opened bloom. No rain-spot has left its stain; no leaf has flecked the rapidly moving insect as it glides in and out amongst the trees; here, in fact, we have perfection.

When the butterfly had steadied itself it closed its wings again; but it had felt the possession of this new power. This became apparent shortly afterwards, for without any warning,

it suddenly and silently sailed from the branch on which it rested above its pupa and alighted most gracefully with outspread wings upon a leaf of a buckthorn shrub close by (Fig. 16), the soft sheens and shades of its velvety clothing appearing most fascinating in the sunlight.

These two preliminary movements were only the beginning of greater things that were to follow, and each rest became shorter

FIG. 15.—It opens its glorious wings and balances itself there for a ew moments. Then, having felt the new power it possesses, it suddenly and silently sails from the branch.

and shorter, while each flight became longer and stronger. At last our butterfly arrived at an open space where sunlight reigned in all its glory. And there for the last time we stand watching this glorious creature that we have seen develop from the tiny and wonderfully-sculptured egg, through the green and spiny caterpillar that so dearly loved honeysuckle leaves, the gilded, green, and brown chrysalis that hung so strangely upside-down on the branch, and, finally, into this handsome butterfly, clothed

in its wondrous suit of inimitable velvet, woven—from what and from where? Suddenly it swerves aside to a bramble flower, freshly developed like itself, and, unrolling its long tongue, sips of the sweet nectar, for it no longer has mandibles for biting green leaves, these biting organs disappearing with the caterpillar stage, but now lives upon the soluble sweets that the flowers provide.

After the butterfly has quenched its thirst it becomes more

Fig. 16.—It alights with outspread wings upon a leaf of buckthorn shrub near by to rest and sun itself.

buoyant than ever; and then, rising high in the air, plunges headlong into the sunny path of its life. It is useless attempting to follow it farther; it is away on one of those wild love-chases such as we saw in the woodland glade. Soon it will find its mate—and then the whole cycle will begin over again.

It remains, in conclusion, but to note that the egg which produced our embryo butterfly was, as previously stated,

deposited on July 16, and that the development of egg and caterpillar occupied a little over ten months. Then came sixteen days for the chrysalis period, which leaves about six weeks to complete the year. This period is occupied in mating and in depositing its eggs by the female insect; and an allowance must be made for dull weather intervals, when the insects do not fly. Given sunny weather, however, mating may take place almost immediately after emergence. And then, having fulfilled that function of their lives for which Nature provided these insects with wings of lovely hues, and having no further function to perform in life, they seek a shady spot beneath a leaf, or in some similar situation, and there, if no insectivorous animal abruptly removes them, they slowly and silently drop out from the tide of life.

CHAPTER II

The Life Story of a Horse-chestnut Bud

AS spring draws near we look eagerly forward to that time when the buds of trees will put forth their livery of delicate green, for then we know that the season of short, dull, and dreary days has ended. We, of course, look to, and speak of, "the time of bursting buds" with gladness in our hearts, but even then it may be with little thought for the wonderful processes of Nature that are at work. How comparatively few of those who hail with delight the first glimpses of green that decorate tree or hedgerow have considered the wondrous means and mechanisms employed by Nature in carrying out this great annual process—a process which, but for its familiarity, would always fill us with astonishment, one which from its commencement changes almost hourly the aspect of the whole landscape! How marvellous it all is when we come to think of it! What mysterious force is it that brings about this stupendous change? What are these tiny buds that push aside the strong, brown, membranous covering scales, and from within reveal, first, tiny leaves, and later, from between these leaves, a minute branch which slowly lengthens out, leaving behind it, as its apex travels ahead, a wonderful display of fresh green leaves, all perfectly and orderly arranged about its axis, until by autumn it becomes quite a strong-looking twig on the parent tree? The material grows before our eyes; but of what is it built, and whence come the materials for its growth? These are but a few of the questions that will suggest themselves to us the moment we begin to think of the bursting bud.

Let us begin at the beginning. We will consider the bricks so to speak, of which the bud is built, for a bud can no more be built without building material than can a house. The plant bricks, though, we must call "cells," for early observers with the microscope in the seventeenth century, when they discovered the units that build up plant structure, called them cells because, aggregated together, they somewhat resemble the cells of honey-combs. The individual cell, although extremely minute, yet possesses all the functions necessary to a living organism. It has nutritive powers; it can respond to external, and internal stimuli, and it can reproduce itself by simple division.

If, by means of the microscope, we examine a thin slice or section cut longitudinally through a young leaf-bud, we find that the apical point, or growing tip (which occupies the centre of the bud), is built up of a mass of small-celled tissue, the cells of which are continually dividing to form others just like themselves, and so multiplying their numbers. In this way a mass of tissue is being heaped up in a perpendicular direction, and so the developing twig goes ahead. If this were all that happened, though, we should have only a long, straight stem or branch produced. But as the developing tissue increases the length of the stem, it occasionally leaves just behind its growing point, in regular succession, tiny portions of its dividing tissue, and these isolated parts of the tissue then grow rapidly in a lateral direction, forming the starting-points of leaves. However, if we examine the tissue ever so carefully to detect where the stem and the newly formed leaf-tissue separates, we shall find no distinction; at both points we find cells of identical appearance.

In illustration Fig. 17 is shown the central growing mass within the heart of a bud, crowned with two tiny newly formed leaves, and below and outside these two slightly older leaves may be seen springing from the sides; these leaves overtop the growing axis, and are beginning to assume the finger-like form characteristic of horse-chestnut leaves. In this way the leaves first formed protect the younger ones, and also the tip

of the growing axis. In Fig. 18 is shown a further magnified view of the two youngest leaves, to reveal the minute developing cells of which they and the growing point are built.

Of the active forces within these tiny cells which cause them to continually reproduce themselves by division, and in this manner produce the "bricks" or cells which eventually

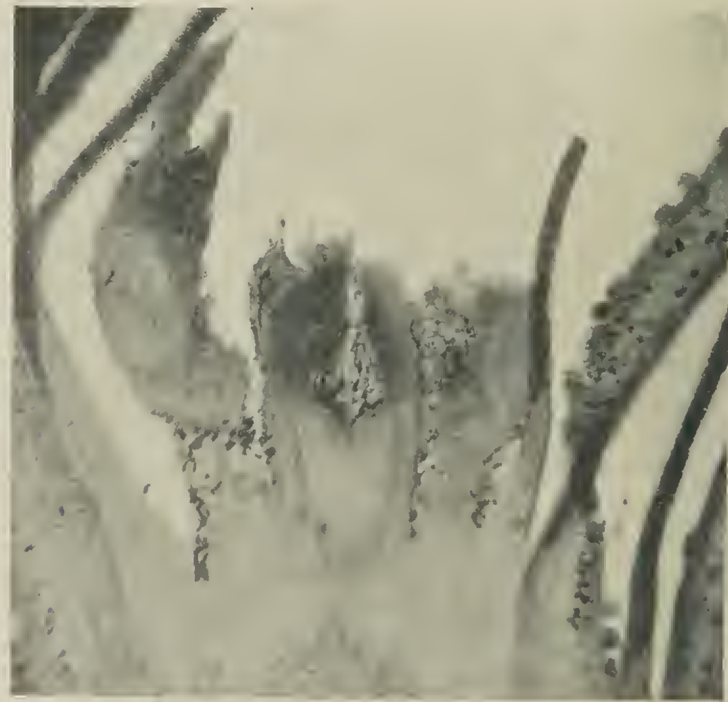

FIG. 17.—A magnified view of the heart or central part of a young horse-chestnut bud, showing the tiny leaves developing at the top of the growing axis. Outside are seen some of the membranous scale-leaves that protect the more tender tissues within.

differentiate to form the plant structure, we know nothing, and have to content ourselves with defining them as "life" forces; and of the phenomenon of life, science has as yet advanced no plausible explanation.

In this way, by continual division and multiplication of the cells at the growing point, the leaves and branch structures are

built up. Later, when the cells become very numerous, they begin to assume various permanent forms, and so become adapted to the different duties they have to fulfil in the economy of the whole; but growth consists in the formation of millions

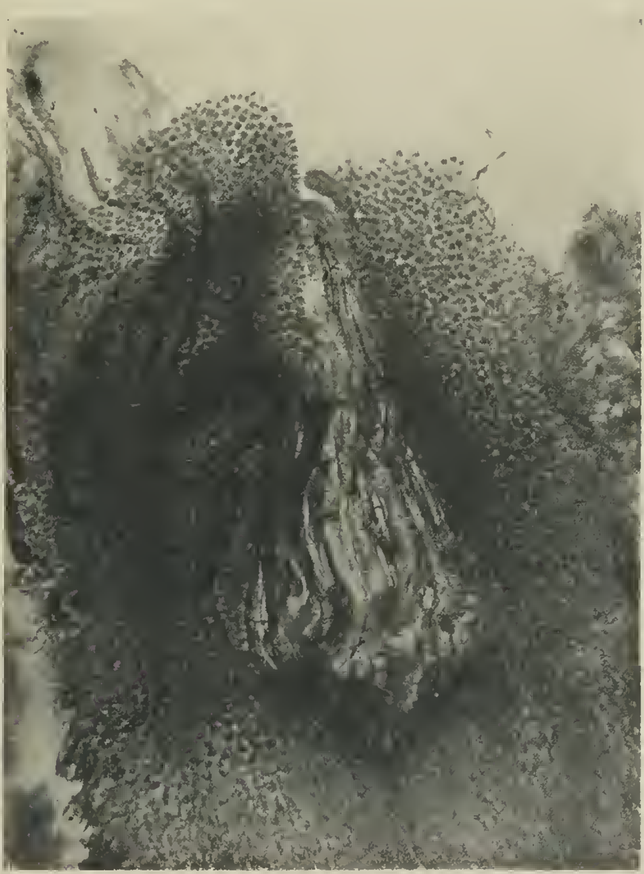

Fig. 18.—A much more magnified view of the two youngest leaves seen occupying the centre of Fig. 17, showing the innumerable minute cells which, hy their continual division, build up the plant structure. The woolly hairs which protect the young leaves should also be observed developing along with the cells.

of cells, thus building up the hard and soft tissues of the bud and the branch that it gives origin to.

Having now grasped the idea as to how the young leaves of the bud originate from the growing point within, and then

continue their own development, we may turn to external happenings.

In Figs. 19, 20, and 21 is shown the daily development of two leaf-buds, and a glance at these illustrations will make it obvious enough how the growing points within the buds have pushed themselves forward and are well on the way to form strong branches; while the newly formed leaves are seen to be

FIG. 19.—The heart of the bud becoming a leafy shoot.

developing on their own account. However, the growing powers of the individual leaves are not unlimited, like those of the growing point, but are restricted to their own development, and when they have reached their full size they lose their growing power, and commence to work in the general economy of the plant—of which more anon.

Having now learned something of the method of growth, we may proceed with the life story of an individual bud,

commencing at the beginning of events which are apparent to the eye.

The date was March 25, the year need not concern us. It was a glorious morning, and the bright sun very welcome and cheering. Apparently, it was also cheering to the leaf-buds on a great horse-chestnut tree near by. At all events, the buds on the ends of the branches seemed so elated and full of energy that many of the strong, brown protective scales, which had so

Fig. 20.—The buds shown in Fig. 19 as they appeared the following day.

thoroughly resisted wet, cold, and frosts alike throughout the winter months, were now finding it very difficult to restrain the young green leaves within their keeping from bursting forth to greet the sunshine whose warmth they felt.

During the previous autumn, when the buds were formed, the last protective device of the plant was to convert the outside leaves of each young bud into strong membranous enveloping scales, and these scales were provided with curious

glandular hairs which secreted a substance called "bud-glue," a mixture of gum and resin. By means of this bud-glue the scale-leaves firmly attached themselves around the outside of the bud, and a varnish-like coat of the same substance was also spread over their outer surfaces. Of course, at the end of the autumn the growing activities of the plant had almost ceased, and the young leaves were then not strong enough to

FIG. 21.—The same buds on the third day.

resist the pressure brought to bear on them by the strong scale-leaves, so there they remained huddled together and securely protected by their strong outward armour.

Now, however, things were different. The warm sun had for several days past made its presence felt, and the tiny hairs on the roots of the tree deep down in the earth had responded to its life-giving warmth, and were all greedily absorbing moisture and conveying it to the cells of the roots to which

they were attached. Now, many of these cells contained mineral salts having great affinities for water, and these salts quickly absorbed the water as it came their way. In due course these salts would have their fill, and then the salts in the cells above them would likewise attract the water, and so an upward current would be set up. Presently this current of

FIG. 22.—On March 25 the warm sun melted the sticky bud-glue, and the outermost scale-leaf slowly relaxed its hold.

crude sap would meet with tube-like tissues, which once were rows of cells standing upon each other like those we saw forming at the growing point, but later the transverse walls of these cells dissolved, and so these rows of cells became tubes or water-mains, as it were, which traversed the whole length of the plant, both through root and stem. When the sap

current reaches these tubes it rushes upwards at a great pace, and soon every bud and growing part is plentifully supplied with the necessary sap to continue its development.

All this had been going on very quietly for many days past, and now, on this lovely March morning, it told its tale. In fact, the outermost scale on one large bud at the tip of a

FIG. 23.—The next day the opposite scale-leaf gave way—and then matters went on apace.

branch could no longer resist the exuberance of the young leaves within. The warmth from the sun melted the sticky bud-glue and made the scale-leaves shine so much that they appeared to be perspiring profusely with their efforts to restrain the lively young green leaves they had to protect. But this scale-leaf was slowly relaxing its hold, as if fairly beaten

(Fig. 22); although strands of the sticky bud-glue stretched from scale to bud as if endeavouring to still retain it. This, however, was only the beginning of greater events that were to follow.

Next morning, when I saw the bud, something more had taken place. The developing leaves, having to overcome an

Fig. 24.—By the third day a second pair of scale-leaves had let go, and then the bud rapidly increased in size.

ever-lessening pressure from the scale-leaves without, had, in the course of the twenty-four hours, visibly increased in size, and the opposite scale-leaf had also released its hold (Fig. 23). Then matters went on apace; one could almost see the bud grow while watching it. On the third day the next pair of scale-leaves had given way (Fig. 24); and by the fourth day

an inner and paler-coloured pair commenced to release their hold (Fig. 25). Meanwhile, the four outermost scales were turning right back out of the way, and, at the tip of the bud, some peculiar white hairy leaves were appearing. Also, we should notice that the two smaller buds below are carrying out almost exactly the same movements.

Fig. 25.—On the fourth day the inner scales began to bulge open, while the four that had previously opened were turning right back out of the way.

On the fifth day the paler-coloured pair of scales had become quite free (Fig. 26); and by the sixth another pair inside these had broken away also (Fig. 27). By the seventh day the scale-leaves began to appear insignificant, for the white mass of hairy leaves now conspicuously occupied the centre of the bud (Fig. 28). On the eighth day the last and innermost

pair of scale-leaves were rapidly pushed aside (Fig. 29); so that by the ninth day the true leaves of the plant were exposed to view, and forthwith began to open out from the growing axis; and here our bud makes startling changes, for it now begins to turn into a leafy branch (Fig. 30).

Fig. 26.—The first inner pair of scale-leaves to open proceeded on the fifth day to follow those turning back and—

We observed how carefully the plant protected the young leaf-buds in autumn by means of the strong, brown, varnished scale-leaves, and now as these leaf-buds develop in the spring we have revealed to us another wonderful protective contrivance. The young leaves at first are very tender, and need protection from both the warm sun of midday and also the

cold and perhaps frost of night. Both requirements are beautifully and simply met by providing the developing leaves with a dense covering of woolly hairs, which shade them from the fiercest rays of the sun and likewise keep away the cold. By means of these woolly hairs all the green parts of the leaf

FIG. 27.—by the sixth day another inner pair had broken away also. Meanwhile, the two smaller buds below had commenced almost exactly the same movements.

are hidden from view for some time after the leaves have opened out from the axis, and Fig. 31 shows us the bud on the tenth day with the young leaves spreading out all wrapped in their woolly coats.

It will be remembered that horse-chestnut leaves are not, like elm or beech leaves, all in one piece, but are compound

leaves, having generally five or seven finger-like leaflets. In Fig. 32 is shown the bud on the eleventh day, and the leaflets are then beginning to become detached from each other; but each leaflet, it should be observed, is still covered with its coat of protective woolly hairs. One other important thing should

FIG. 28.—On the seventh day a white mass of hairy leaves conspicuously occupied the centre of the bud.

be noticed also. If we look at the tip of the bud—or shall we say branch, for it can scarcely be called a bud now—we observe a mass of little rounded bodies pushing their way forward. What are these objects?

The bud we have watched develop is not like the bud illustrated in Figs. 19, 20, and 21, a leaf-bud only, but is a

flower-bud besides, and, instead of developing into a leafy shoot, it will become a flowering branch. This also accounts for its comparatively large size during its early stages (see Fig. 22). The two buds simultaneously developing below it

FIG. 29.—By the eighth day the last and innermost pair of scale-leaves were rapidly pushed aside.

are leaf-buds only, and will develop, more or less, like those in Figs. 19, 20, and 21.

We will now neglect to visit our bud for a whole week, and then we shall see what a striking difference it presents. This is shown in Fig. 33; the bud is now no longer a bud, but a branch bearing leaves and buds—flower-buds. What was once the heart of the bud is now a group of flower-buds on the

tip of a branch. The leaves, too, have now exposed their green surface, while the woolly hairs which protected them in their babyhood are fast falling away.

Once more we neglect to visit our bud, and this time for three weeks. What a change meets our eye then! We can

FIG. 30.—On the ninth day the true leaves of the plant were exposed to view, all wrapped in woolly hairs.

now no longer conveniently photograph it at natural size, but have to reduce it considerably (Fig. 34). The leaves have all lost their hairy covering, and stand out fresh and lovely, crinkled and bright green. The two smaller leaf-buds beneath have now also become leaves, while the flowering branch has elongated and exposed its clusters of flower-buds.

Again we leave an interval, and at the end of another fortnight we once more review our developing branch, which has now grown so large that it again has to be considerably

Fig. 31.—By the tenth day a pair of them were spreading themselves out to the light.

reduced in photographing (Fig. 35). (N.B.—To form some idea of the amount of reduction, the thickness of the base of the branch should be carefully observed in each example illustrated).

The leaves have now attained their full development, and are engaged in spreading out their tissues to the fullest possible extent to the sun's rays, that they may absorb the light and energy those rays contain, and then utilize it in building the

FIG. 32.—The finger-like leaflets became detached on the eleventh day and, at the tip of the bud, a mass of rounded bodies appeared to view.

branches, flowers, and fruits of the tree; for sunlight is the motive power that supplies the energy necessary to the growth and development of both plants and animals.

The centre of each of these pretty flowers arranged along the flowering stalk is occupied with a tiny ovary, in which

ovules or embryo seeds are produced. In due course the scent of the flowers attracts the early-wandering bees in their direction, and eventually the pale-coloured petals catch the eyes of the insects as they follow up the scent, and they im-

Fig. 33. A week later (April 12) our bud had become a branch, bearing leaves and buds—flower-buds.

mediately proceed to seek for the nectar or honey the flowers provide.

Of course, the horse-chestnut tree does not provide bees with nectar for nothing in return. Its stamens or pollen-producing organs are arranged so as to hang well outside the

flower, and form a landing-stage for the bee to alight upon; and amongst these stamens the stigma or sensitive surface of the ovary is placed. In this way, when the bee comes to rifle the flower of its nectar, its legs and body get dusted over with

FIG. 34.—Three weeks later still (May 3) the leaves had all lost their hairy covering and stood out fresh and lovely in bright green, while the flowering branch was rapidly developing. N.B.—The branch is, of course, now considerably reduced in size in the photographs.

pollen dust of the stamens, which is the male fertilizing element of the flower. So the bee becomes an unconscious agent in the fertilization of the flowers, by conveying the pollen of one flower to the stigma of the next.

After the stigmas of the flowers have been pollinated in this manner, the substance of the tiny pollen grain finds its way to the ovule at the base of the ovary, and combines with it. The ovule then starts to rapidly divide its cells to form others. In

Fig. 35.—At the end of another fortnight (May 17) the flowering branch had reached the height of its glory, and the large leaves were spread out to the sunlight.

short, this act of fertilization has started a new growing point; and as the numerous newly formed cells accumulate they aggregate together, and soon a seed is produced. Hence the object of the flower was essentially that of reproduction.

However, all the flowers do not produce seeds, for, if we watch the flowers after fertilization has taken place, we see most of them dwindle away and decay. Two or three, though, generally remain, and, as their petals shrivel up, their ovaries begin to swell into rounded bodies, while the top part of the stalk, which bore the other flowers, gradually dries up, all the energy of growth being now directed to the developing fruits

Fig. 36.—Two months later (July 17) the ovaries of three of the lowest flowers had developed into smooth, green fruits, which nestled amidst an expanse of more than two feet of leaves.

with their seeds within. In Fig. 36 we see the branch two months later, when its leaves have an expanse of more than two feet, and centred amongst them are three ripening fruits.

At this stage, about the continually thickening wall of the ovary, which now forms the covering of the growing seed, sharp, strong prickles begin to develop, to protect the rich

stores of nourishment contained in the seeds within from outside animal enemies that might prey upon them. Two

Fig. 37.—At the end of another two months (September 17) the fruits had almost ripened, and were protected with strong, prickly coats.

months later still the fruits are fully armed, and appear as shown in Fig. 37, which, it should be observed, is only the

fruit-bearing part of the branch, and has, therefore, permitted photographing on a little larger scale.

FIG. 38.—Two weeks later still (October 1) these prickly covers split, each into three valves, and exposed three shining brown seeds—the harvest of the bud and some of the offspring of the tree.

Two weeks later these prickly covers split, each into three valves, and disclose three cells, each of which should really possess a polished brown nut or seed. But it more often

happens that one large nut develops at the expense of the other two—as it did in each case of the examples under observation.

Illustration Fig. 38 reveals the harvest of the bud that we have watched develop from early spring, when its first scale-leaf was pushed aside by the energy of the sun's rays, and out of whose heart we saw arise the woolly protected leaves and, later, the shoot with its clusters of snowy-white flowers dashed with yellow and pink, which slowly changed from flowers to smooth, and then prickly, rounded fruits, whose valves burst apart to reveal some of the offspring of the tree.

Yes, within each shining brown seed is a tiny plant, with a minute leaf-bud at its apex and a delicate root tip at its base, embedded in a rich store of nourishing starches and other food materials which shall nurture this embryo plant until its tiny bud opens out green leaves of its own to the sunlight, and so becomes able to sustain itself, and until its tiny root shall have developed so that it can plentifully supply with watery sap this first bud of a new horse-chestnut tree.

But there may be mishaps. Perhaps some wandering sheep, goat, or deer, may meet with our three seeds as they lie fallen on the ground, and then their stores of energy-yielding starches may provide energy of another kind; it may become animal energy instead of plant energy, when, of course, no horse-chestnut tree can arise from the work of our bud. For although the bitter taste of these nuts protects them from being used as food by man, yet many animals will readily feed upon them. Or another sad fate that may befall our seeds is at the hands of the truant schoolboy, who, with a piece of string and a gimlet for boring holes, seeks for "konkers."

It only remains to add that, by the time the seeds have fallen, the leaves, once so tender, green, and lovely, have become tough, brown, shrivelled, and insect-eaten; they have performed their task, and soon the tree will throw them off. But before it does so, in the axil, or joint, of most of them it places a tiny bud, formed from a minute portion of developing tissue like that we first considered. When the leaf falls it

leaves a "scar" where it has been (Fig. 22), but above that scar is the new bud, with all its potent possibilities for the following spring, when, if all goes well, it will itself start on such another series of wondrous changes and developments as I have recorded in these pages.

CHAPTER III

The Life Story of the Lobster Moth
(*Stauropus fagi*)

THE lobster moth is quite an ordinary kind of moth, possessing no striking features, either in colour or form, distinguishing it in essential particulars from the generality of such insects. But the first time you find the larva or caterpillar of this insect, you wonder what strange animal you have come across; for it is doubtless the oddest and most extraordinary of British caterpillars. The popular name of this insect is indeed derived from the fanciful resemblance which its caterpillar is supposed to bear to a lobster, although it does not really resemble anything to be found in Nature.

The lay individual's idea of a caterpillar is, generally speaking, a soft, round-bodied grub, sometimes smooth and sometimes hairy, with a very indefinite number of tiny legs, by means of which it crawls about and clings most tenaciously. The larva of the lobster moth is something very different, however, and possesses quite original ideas as to what a caterpillar ought to be, both as regards anatomical structure and the manner in which it should conduct itself generally.

You have only to touch or irritate one of these larvæ to get a most surprising demonstration of annoyance; in fact, if you persist in teasing it, it gets into a terrible rage, and makes such obvious show of its anger that, unless you are well acquainted with its capabilities, you might think it wise to keep just out of its reach. I will endeavour in the course of this chapter to depict, by means of photography, the terrifying

attitudes assumed by one of these caterpillars when angry. But I want you first to start with me and trace the history of this curious animal from its earliest moment—namely, when it leaves the egg, and then we shall see the various strange tactics it pursues throughout its six or seven weeks of caterpillar life.

In the first place, the eggs which the female moth deposits about oak and beech trees are well worth glancing at. They

Fig. 39.—The eggs of the lobster moth, magnified about twenty-five diameters.

are shaped somewhat like a skittle-ball, and are about the twentieth of an inch in diameter, of a pearly white or very pale green colour, and their shell surface is beautifully reticulated with a delicate network pattern, although the latter feature needs the microscope to reveal it. In illustration Fig. 39 three eggs are shown as seen by means of this instrument.

After the course of a fortnight, or thereabouts, from the

time these eggs were deposited the young larvæ emerge, and from the moment of their appearance they are novelties considered from a caterpillar point of view. The usual appearance of a larva after emergence from the egg is that of a tiny grub, difficult to see, and very slow in movement. But the egg of the lobster moth is one of the largest deposited by British moths, and immediately its shell breaks there appears one of

Fig. 40.—When the caterpillars of the lobster moth are first hatched they resemble ants; two can be seen in the illustration, one on the edge and another on the central vein of the leaf.

the most lively and quaint little animals you can possibly imagine—considering it is a caterpillar.

In illustration Fig. 40 two of these caterpillars are shown photographed directly after their emergence from the egg. One will be seen resting near the base of the central vein, or

mid-rib, of the leaf, the other on the edge of the same leaf—in the characteristic feeding attitude.

The young larva is of a shining or polished brown colour, and what makes it look so uncaterpillar-like is that the second and third pairs of legs are so long as to seem altogether out of proportion with its general anatomy; in fact, they look very like legs borrowed from some entirely different insect. The first of the three pairs of anterior legs—which are true legs, the clasper-legs being used only for clinging purposes during the caterpillar stage—are shorter than the second and third pairs, and are carried held up in front of the head; the remaining two longer pairs keep up a rapid quivering movement, with an occasional wave in the air, both when the larva is walking and holding by its claspers, ceasing only when it is at rest. Then, too, it has a curiously forked tail, which it keeps more or less elevated in the air, and along its body are a number of pointed humps; but these details become more obvious as the caterpillar gets older, for reasons which we shall understand later.

This incessant quivering and waving of the second and third pairs of long legs, and the lively way in which the larva moves about, combined with its shining brown colour, leave a distinct impression that you are looking at an ant. Now, ants are insects provided with very strong jaws or mandibles, and are well able to take care of themselves, gaining much respect from would-be enemies on this account. It is apparent, therefore, that this resemblance to an ant carries with it considerable protective advantages for the caterpillar.

Of course, if we look closely at the larva we see that it is not an ant, but a first impression counts for much in the "struggle for existence" amongst living things. For example, there are ichneumon flies—insects which deposit their eggs in or on the bodies of caterpillars; and the grubs hatched out from these eggs feed parasitically on the substance of the larva. Now, an ichneumon fly, while seeking caterpillars, frequently meets with ants amongst the leaves and stems, and very respectfully allows them to pass, a habit which is strengthened in the species as time goes on. Hence, being in

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the habit of avoiding ants, the ichneumon fly, as you can readily imagine, does not attack the lobster moth caterpillar, which at this stage so much resembles an ant. If by any chance the fraud should be detected, what would happen then? In all probability the caterpillar would escape just the same; its somewhat ant-like character, combined with that indefinable and mysterious something else which it possesses, would doubtless make it seem too risky a venture for its enemy to undertake. This mimicry of an ant for protective purposes is by

FIG. 41.—Lobster moth caterpillars when twenty-one days old resemble bits of twisted leaves and scales of leaf buds, while resting.

no means unique; Belt, Wallace, and other naturalists have pointed out many other insects which have found it profitable to assume an ant-like appearance, such instances being abundantly evident in tropical countries, where the life competition is keen.

So the baby lobster moth apparently becomes an ant for the first week or ten days of its life. As it grows, however, it gets too big for the ant dodge, and is obliged to give up this kind of tactic and try another device. Its mimicry then takes

two different forms, one for use while resting and the other when in movement.

In the resting attitude it becomes inconspicuous by resembling a piece of dry and curled-up leaf. This manœuvre is effected by placing together the two forks at its tail and so turning them into a likeness to a leaf-stalk; and then, hanging its body down from a stem or leaf, it doubles or folds up its four long legs, and allows these to hang down in a bunch in

FIG. 42.—The caterpillars when one month old.

front of its head, and, as Professor Poulton has shown, these strongly suggest the brown scales of leaf-buds.

In illustration Fig. 41 three of these larvæ are shown resting in the attitude described above, when three weeks old. It will be observed that they usually rest against that portion of the leaf on which they have been feeding, and at first glance do not look unlike the missing portion of the leaf, shrunken and shrivelled and still clinging to the stalk. Another example is shown in Fig. 42, which represents two larvæ when about a month old. In about six or seven weeks they are full grown,

and a full-fed larva is shown resting in Fig. 43. In these latter two illustrations the same characteristic of resting near the leaf on which it is feeding is again exhibited, and the resemblance to a withered and dried-up leaf, as is seen, becomes very much intensified as the larva increases in size.

These caterpillars cannot always be at rest, however, and, as it is not the custom of shrivelled leaves to walk about and

Fig. 43.—A full-fed larva resting, and resembling a dry and shrivelled leaf.

consume other green leaves, Nature has provided these larvæ with further means of protection for use when feeding, or if attacked while in movement, and these we will now proceed to consider.

First, we may glance at the caterpillar peacefully feeding (Fig. 44), and observe how it makes straight cuts up the edge of the leaf, clearing away the soft parts until it reaches the

central vein or mid-rib. It eats rapidly, but not for long together, feeding for a short time and then resting, and then feeding again, and so on.

Now, when one of these caterpillars is found in this way enjoying its meal of beech or oak leaves it is always on the alert, and at the slightest disturbance of the leaves in its near neighbourhood it instantly stops feeding, lifts up its

FIG. 44.—The larva peacefully feeding.

anterior legs, and at once becomes the withered leaf again, just as if it knew the value of this means of protection. Of course, the larva has no knowledge of its mimetic resemblance to its surroundings, these features being the outcome of accidental variations that have served a favourable turn in the development of the species, and which therefore became hereditary.

After being disturbed in this fashion it generally rests for awhile before feeding again, resuming its meal after things have quieted down. Such is its ordinary careful method of avoiding discovery by its enemies. It sometimes occurs, however, that it has a real enemy to contend with, and then we see a very different display of manœuvres.

In illustration Fig. 45 is a caterpillar which, just a moment

FIG. 45.—A larva, when touched, stops feeding and endeavours to frighten off its enemy by looking ferocious—

before it was photographed, was feeding as quietly as the example shown in Fig. 44. It will be observed that it has detached its foreparts from the leaf, and is raising both its head and tail; and this movement was owing to the fact that I gave it a sharp touch with my finger just as I was about to make the exposure for photographing it. It continued this movement in a slow and stealthy manner until it reached the

position shown in Fig. 46, in which it held itself perfectly still, bearing a look which seemed to plainly imply, "I am ready for you now, sir, if you care to do that again!" Not suffering from nervousness, I did it again; in fact, I not only touched it, but blew at it, because I wanted to see and photograph it while in a really desperate mood. The blowing seemed to aggravate it immensely, and immediately its head and tail were

FIG. 46.—and slowly becomes like some ugly spider.

brought closer together, and its long second and third pairs of legs were quickly put into action. These waved in the air and trembled and quivered with apparent rage as the insect turned its head in most angry fashion towards me. In the illustration Fig. 47, you see it at this interesting stage, where the rapid movements of its legs give them a somewhat indistinct appearance.

I immediately followed up this first assault by another of

an exactly similar nature. At this second blowing the larva reached the height of its rage and demonstrations, and Fig. 48 shows it at this moment, where it will be seen to have worked its legs at a speed which has only permitted one—which had evidently just reached the limit of its movement and was about returning—to photograph clearly. Its head and tail are also seen to have come closer together as its rage increased; the

FIG. 47.—If further annoyed, it waves its legs about and quivers with rage.

latter organ is gently worked from side to side while the rapid leg movements are taking place.

I both touched and blew at it again after this, but when it found that the trick was not working it fell back on its old dodge of being a dried-up leaf again. I say "trick" advisedly, because all of these terrifying attitudes are simply bluff, and the caterpillar does not possess one real weapon of defence, and is, therefore, quite harmless. It depends entirely upon its

alarming demonstrations to delude its enemy into the belief that it is able to do some very desperate things if driven to it.

The interpretation of these novel manœuvres was originally suggested by Hermann Müller. This naturalist observed that ichneumons—the flies previously referred to as living on caterpillars during their larval stages—were rarely ever found in spiders' webs, and that these insects know well how to avoid

FIG. 48.—If you persist in annoying it, its rage becomes still more intense, its legs waving rapidly, and its tail working from side to side.

the attacks of such foes. It naturally follows, therefore, that a larva which bears a resemblance to a spider would, in a large measure, be protected against such enemies.

Really, the lobster moth larva can be compared with no other living animal, because its extraordinary anatomical details, combined with its curious tactics, have struck out quite an original line of defence. As Müller suggests, it approaches

in resemblance a spider, a terrible and very much exaggerated spider it is true, but that exaggeration only makes it the more terrifying. When seen from the front its first and short pair ot legs are held before its head, and represent the spider's jaws,

Fig. 49.—The photograph shown in the previous figure, enlarged to show the black spots beneath the foreparts of the larva (marked with a white +), which it develops in order to deceive the egg-laying ichneumon.

while the two longer pairs quiver, as it were, with the desire to attack the intruder. The turned-up tail helps to suggest the large abdomen which characterizes spiders; especially is this so when seen from behind.

When the caterpillar demonstrated its anger while its

photograph was being taken, it also simultaneously exhibited another less showy but very extraordinary attempt at bluff, which also records itself on the photographs.

On each side of the bodies of these caterpillars, at the lower part of the fourth and fifth rings of the body (indicated in Fig. 49 by a white +) there are two intensely black spots, but these are only visible when the caterpillar is angry or irritated, being covered at other times with a flap of skin. In illustrations Figs. 43 and 44 these spots are covered, because the caterpillar is peaceful, but in Fig. 45 they commence to appear as dark-coloured lines, and as the larva is further annoyed they become greatly intensified, as shown in Figs. 46, 47, and 48. Müller has suggested that these black spots correspond to the wounds or stings made by ichneumons when egg depositing, or indicate other marks of injury, which would in either case warn off the approaching ichneumon, for, with maternal instinct, this parasite always selects a healthy host for her progeny to prey upon, and, of course, one not already occupied; since each ichneumon usually deposits just about that number of eggs on each caterpillar which corresponds with its size and substance, so that the demands of the developing inmates when hatched will be well met. So this is probably only another protective ruse of this wily caterpillar.

One would think that a larva so well protected could never be killed in the open warfare of life, but, as a matter of fact, both moth and caterpillar are scarce, which shows that their "struggle for existence" is a hard one. So scarce are they that a dealer in insects can command as much as three shillings for a moth specimen, and a similar price for a live pupa or chrysalis, while a live caterpillar can be purchased for about half this price. It does not by any means follow that because an insect is provided with highly evolved protective devices, it will survive and be successful in the struggle for life; in fact, these developments only tend to show how keen that struggle has been, and to what devices it has been compelled to resort to hold a place for itself. Of course, the

reciprocal and concurrent developments of the other side—*i.e.*, its enemies—have also to be taken into account, and these may have kept pace with the evolution of all its defensive movements. Probably, therefore, the scarceness of the lobster moth may be accounted for in this way, although one cannot help sympathizing with this wonderful insect, for, as we have

FIG. 50.—In September the caterpillar wraps itself in leaves and becomes a pupa, or chrysalis, for winter.

seen, it has really made a bold and most ingenious stand for its life. But if we knew more of the enemies which keep it in check—of which we know very little—we might conceive a like sympathy for them also, since they must undoubtedly have proved equally or even more ingenious to have kept them level with such tricky manœuvres.

The lobster moth belongs to the London district and

southern counties, Epping Forest and some of the woods of the Upper Thames Valley and throughout the New Forest being favourite localities for seeking this insect.

If the larva survives all the troubles that beset its caterpillar life, about the end of September it assumes its last disguise by pulling about it two or three oak or birch leaves,

Fig. 51.—The chrysalis and cast caterpillar skin, exposed by removing the delicate. but strong, paper-like covering of the cocoon.

attaching them together with silken threads. Inside these it weaves a sheet of delicate but strong paper-like material. This it attaches to a leaf surface by its edges and encloses itself within it. Here in the course of a few days it moults its last caterpillar skin and becomes a pupa or chrysalis. In illustration Fig. 50 the cocoon is shown with an outside covering leaf removed; and in Fig. 51 the paper-like covering

is lifted aside to show the chrysalis, near which can be seen its shrunken caterpillar skin.

The cocoon, with its attached leaves, falls to the ground in late autumn, and lies there amongst other fallen leaves until about June of the next year, when, if all has gone well, a moth wakes up to the fact that it ought to be moving, and breaks its way through its chrysalis shell and cocoon into the open air, and hurriedly steers for the nearest tree, the bark of which it then climbs. It is anything but a pleasant-looking

FIG. 52.—The lobster moth—natural size.

insect at this stage; its wings are short and dumpy and cling about it like wet rags; but if we watch it as it comes to rest higher up the tree, we see the wings slowly expand and open out, and, as they dry with exposure to the atmosphere, their greyish-brown hues, with lighter and darker shadings and markings, become visible; and then we have the last or perfect stage of the curious insect whose life-history we have briefly reviewed (Fig. 52). It is not nearly so handsome as some of our more common moths, but we can always appreciate its sombre hues, because we know what a strange

and interesting animal it was in its babyhood some nine or ten months before. As evening comes on it flutters silently away, seeks its mate, and then in the course of a few days finishes its life functions by depositing its eggs, and so we arrive once more at our starting-point.

CHAPTER IV

The Story of Nature's Units

IT is apparent to the most careless observer that the numerous and diverse individual factors in nature, animate and inanimate, are bound together by certain obvious co-adaptations and adjustments. In fact, there is probably nothing more wonderful in nature than the unity and method which underlie it all, although it is only during the last half-century that science has gathered sufficient facts together to enable it to reveal even the outline of the perfect order of the natural system.

It is plain to everybody that the plant is dependent upon the sunshine and rain, but not so plain that it is equally dependent on the animal; yet science makes us familiar with the fact that the carbonic acid gas, or, to be more exact, the carbon dioxide, exhaled by living animals in the process of breathing, constitutes the chief food source of the plant, the latter, again, by means of its leaves, decomposing it into its primary elements —carbon and oxygen. The former element is utilized in building the plant structure, while the oxygen is restored to the atmosphere for the use of the animal. Thus animals and plants become mutually dependent upon each other—part of the same system.

Of course, the sunshine and rain are equally important to the animal, which could no more live without these life-sustaining factors than the plant. So the sunshine, rain, plants, and animals become inseparably connected. And if we extend our reasoning on these same lines, and say that the plant is connected with the soil, and that the soil is but metamorphosed

rocks, the mineral ingredients of which the plant absorbs and builds into living material, and so on, it would be easy to show that all things organic and inorganic are similarly related. In brief, as we read and learn from Nature's book, we see a wise and connected purpose ever guiding, controlling, and advancing a scheme that is at once stupendous and magnificent, the aim of which is a gradual perfection.

At first the application of such a theory to many phases of life and matter may present difficulties, but it is by comparison of the net results arrived at by the astronomer with those reached by the geologist, the botanist, the entomologist, the chemist, the physiologist, and in like manner by comparing each branch of science with every other branch, and again and again comparing the ultimate results until nothing is left but the final essence of light and truth of the combined whole, that comprehensive knowledge of Nature's workings is obtained.

Let us without specializing, but rather seeking knowledge from any science that may help our purpose, view and consider some of the insignificant nothings or units that surround us in nature, and endeavour to trace the purpose of their existence, and afterwards their relationship with the universal natural systems.

Amongst the lowest forms of animal life is the *amœba* or Proteus animalcule, so called because it is perpetually changing its shape. In its living state it may be found abundantly in ponds and ditches, and structurally considered is simply a minute portion of transparent gelatinous matter, a good specimen being about the size of a small pin's head. It obtains its food by thrusting out portions of its jelly-like substance into contact with the food particles and again withdrawing and enclosing the particle within its body. After obtaining all the nutriment, it ejects the remainder by making an opening in another part of its body. It has no trace of sense organs, or of a nervous system, but is moderately active in its locomotion, this being effected by those same extensile and contractile strands of its gelatinous substance, which it can protrude from any portion of its body.

Here, then, we have presented one of the simplest of living animals, a minute speck of protoplasm endowed with all the necessary faculties of life, and the power to reproduce its kind.

FIG. 53.—Shells of foraminifera dredged from the North Pacific Ocean at a depth of 1800 feet—magnified.

Now, certain forms of *amœba*-like animals are not naked, like the example we have considered, but are able to extract from the water in which they live sufficient carbonate of lime to build themselves a shell-covering. The walls of these shells are often regularly perforated by tiny pores, from which characteristic

the name of *foraminifera* has been derived; and through these perforations the animal protrudes its delicate strands of protoplasm to seek its food. The foraminifera resemble externally microscopical snails, and probably are, or have been, the most

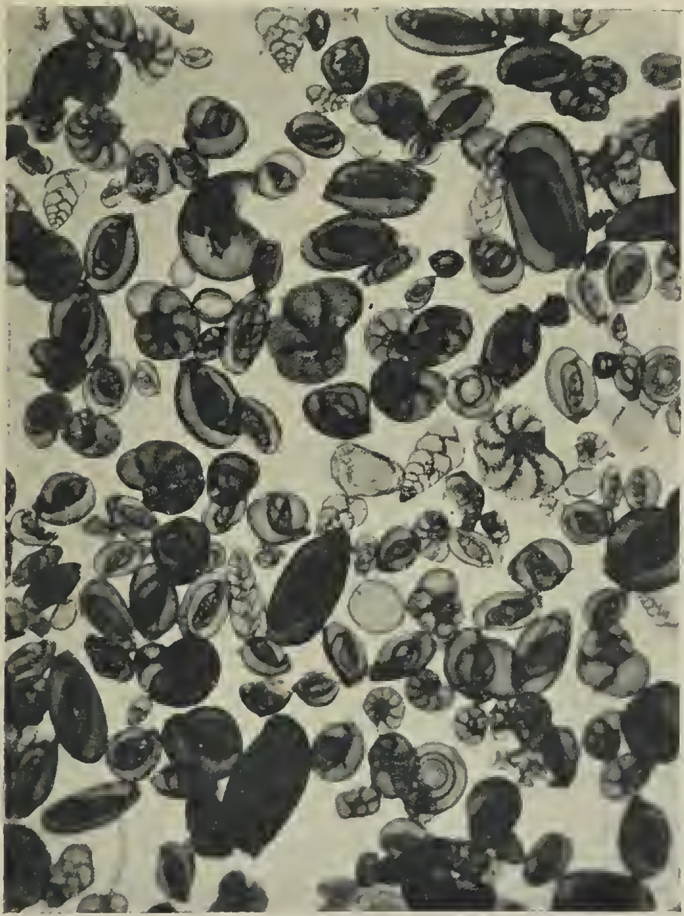

FIG. 54.—Foraminifera from the Adriatic Sea—magnified.

numerous of all created life-forms, and have performed, and are still performing, a very significant and important part in Nature's stupendous schemes.

It will be sufficient for my present purpose, however, as I

shall have to speak of these organisms later, to remark that these tiny animals, the individuals of which are often quite invisible to the unaided eye, are found abundantly in almost all seas, floating on the surface and at various depths, and vast

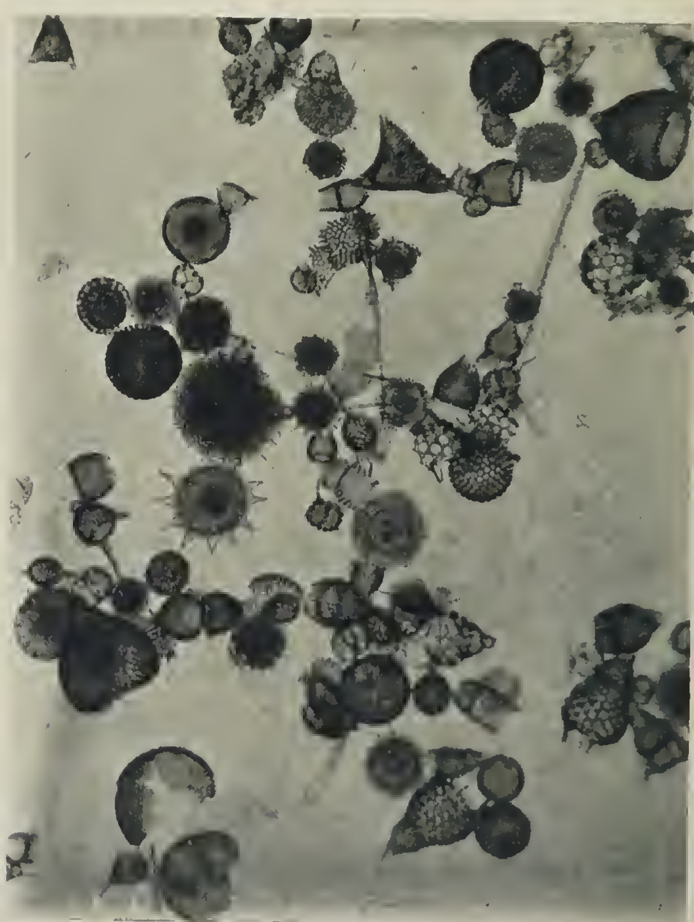

FIG. 55.—Various polycystina from Barbados—magnified.

quantities of their remains are found at the greatest marine depths, as their tiny shells are incessantly raining on the ocean floor as the animals die (Figs. 53 and 54).

Leaving the foraminifera, then, we will consider some other

nearly allied life-forms which, instead of secreting a calcareous shell, clothe themselves with a silicious or flinty deposit. These tiny animals are all microscopic and, like the foraminifera, inhabit the sea either on the surface or at various depths, some species being abysmal, living just above the bottom of the sea. Some of the latticed and spiked forms assumed by the flinty

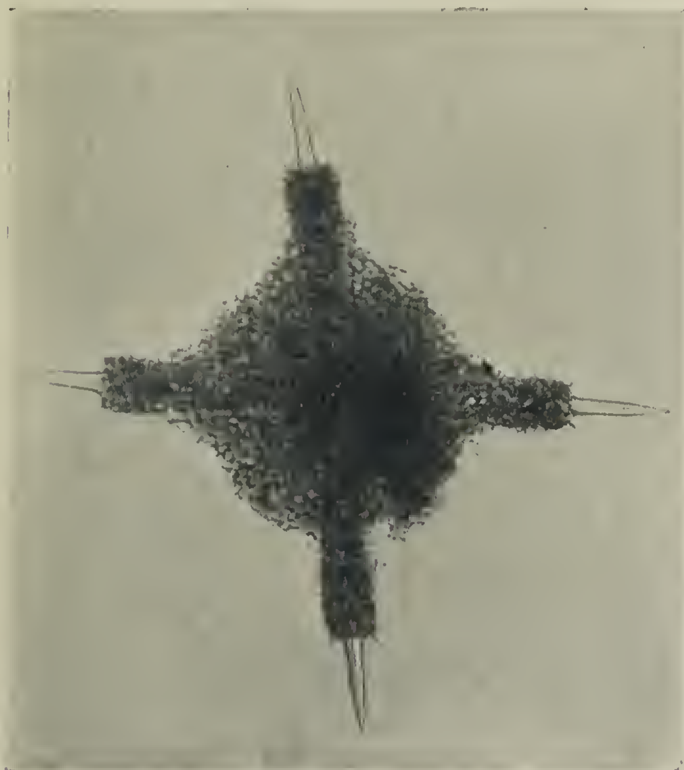

FIG. 56.—A selected polycystina (*Astromma Aristotelis*)—greatly magnified.

envelopes of these jelly-like living specks are exquisitely beautiful and extremely fascinating when viewed by means of the microscope. Their shapes are manifold, and almost invariably they are built in a regular and symmetrical manner, every silicious thread or band strengthening every other. These organisms, like the previously considered foraminifera,

multiply abundantly, and their lives being relatively short, their silicious skeletons are also continually falling to the sea bottom. Formerly these organisms were known as *Polycystina*, but that name has now become gradually absorbed in that of *Radiolaria* (Figs. 55 and 56).

Having now glanced at some lowly forms of animal life, we may consider for comparison a corresponding lowly form of plant life. If we compare the lowest forms of animal life with the lowest plants, it is plain that the two branches of life are here more nearly related than at any other point. Many lowly plants are endowed with the power of locomotion in water, a characteristic common to the lower animal organisms; and likewise, it is also in less highly organized and specialized forms of plant life, that occur those exceptions to the great and ruling laws which govern the vegetable kingdom, these exceptions pointing in the direction of animal characteristics.

This being so, it is not surprising to find living amongst these foraminifera and radiolarians certain minute unicellular plants called *diatoms*, which, like the previous-mentioned organisms, are built up of a tiny speck of living protoplasm. But considering that we are dealing with plant forms it may be surprising to learn that these microscopic plant atoms, like the animal organisms, secrete from the surrounding waters a shelly covering; and, as with the radiolarians, it is a silicious shell, beautifully and wonderfully made, but instead of being strands of silica arranged into basket- and vase-like structures, these valves or shields assume forms which might be compared to microscopic pill-boxes, one side or shield being made a little larger than the other, so that the smaller fits into it, the two halves enclosing between them the tiny jelly-like plant. Externally, these silicious shells are exquisitely sculptured with symmetrical markings and chasings of unimaginable minuteness. So delicate are these markings that it is only with the highest powers of the best modern optical instruments that many are at all discernible. Their external contour is as varied as the radiolarians, or even more so, every imaginable and extraordinary form conceivable being produced by the

different genera. In their remarkable rate of increase these diatoms may also be compared with the animal organisms we

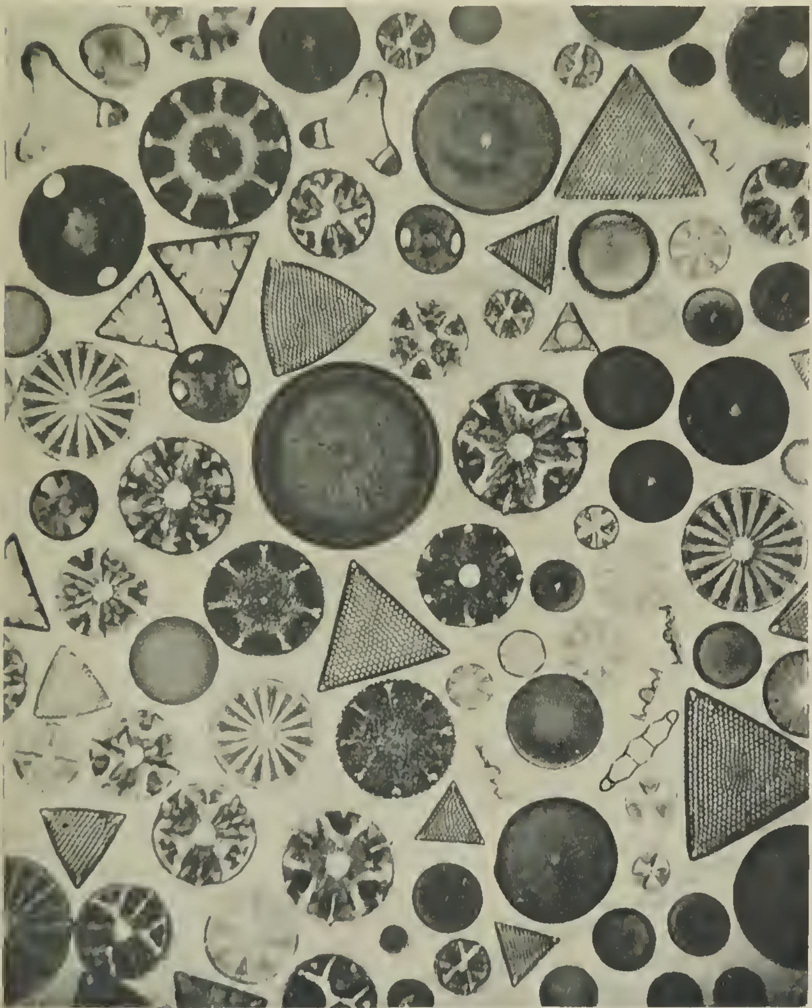

FIG. 57.—Silicious shields or shells of the microscopic plants called diatoms, from Hungary—considerably magnified.

have considered, and as their flinty shields are not easily perishable in water, these minute and beautiful cases likewise keep increasing and showering down to the deepest depths of

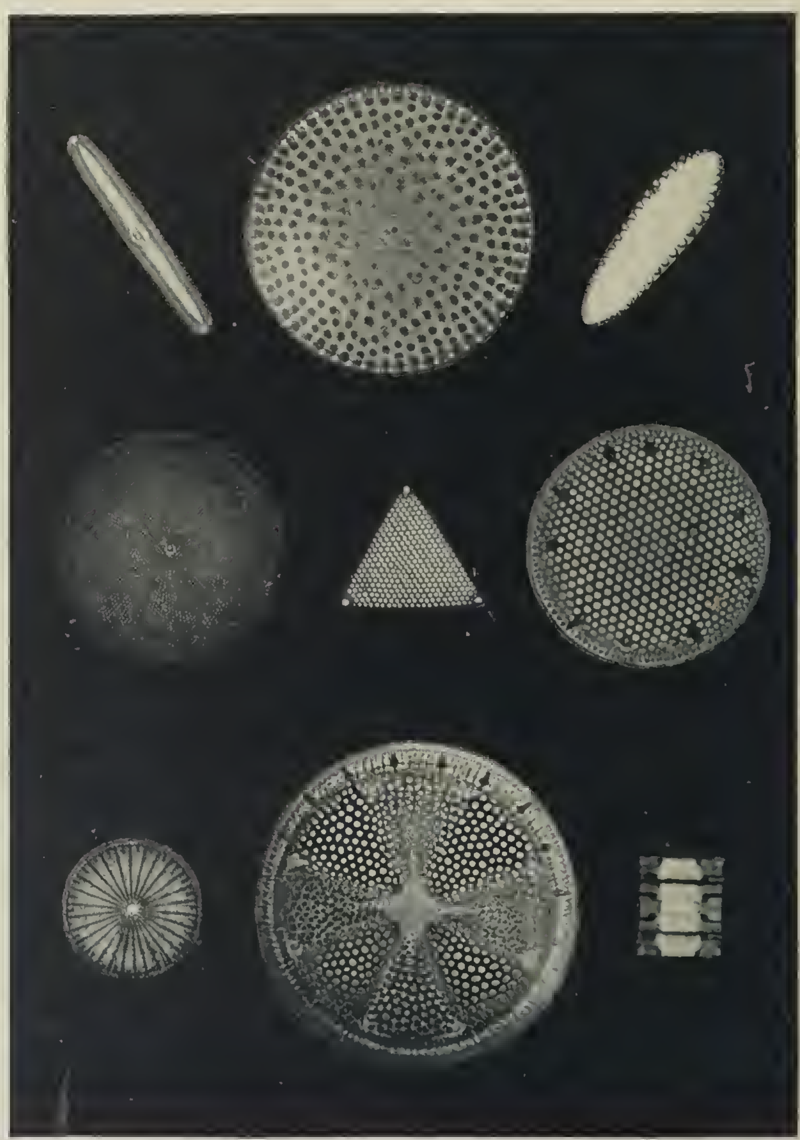

Fig. 58.—Some selected forms of diatoms, from various parts of the world—enormously magnified.

the ocean, and so great is this deposit that estuaries are frequently considerably shallowed by diatom accumulations (Figs. 57 and 58).

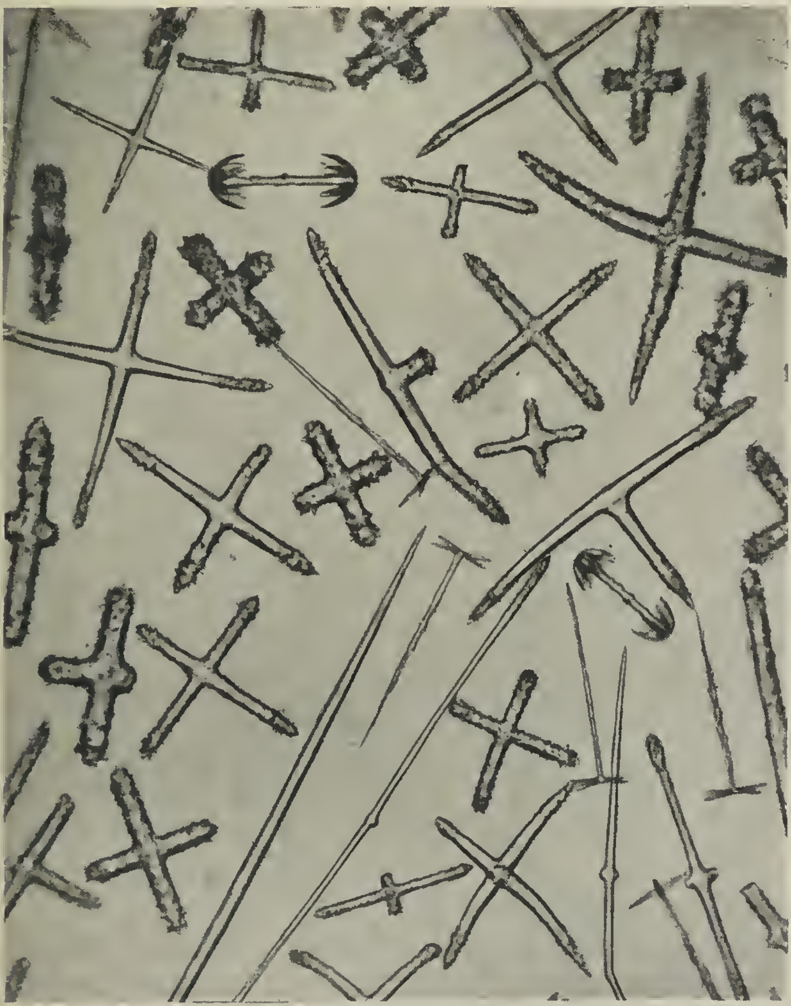

FIG. 59.—Silicious spicules from the glass rope sponge (*Hyalonema mirabile*)—greatly magnified.

Let us now glance at a slightly higher form of animal life, and this brings us to those curious formations called "sponges,"

which for so long a time provided a "bone of contention" for scientists, but which now are almost universally referred to the animal kingdom.

A sponge is rather a complicated structure to define in a

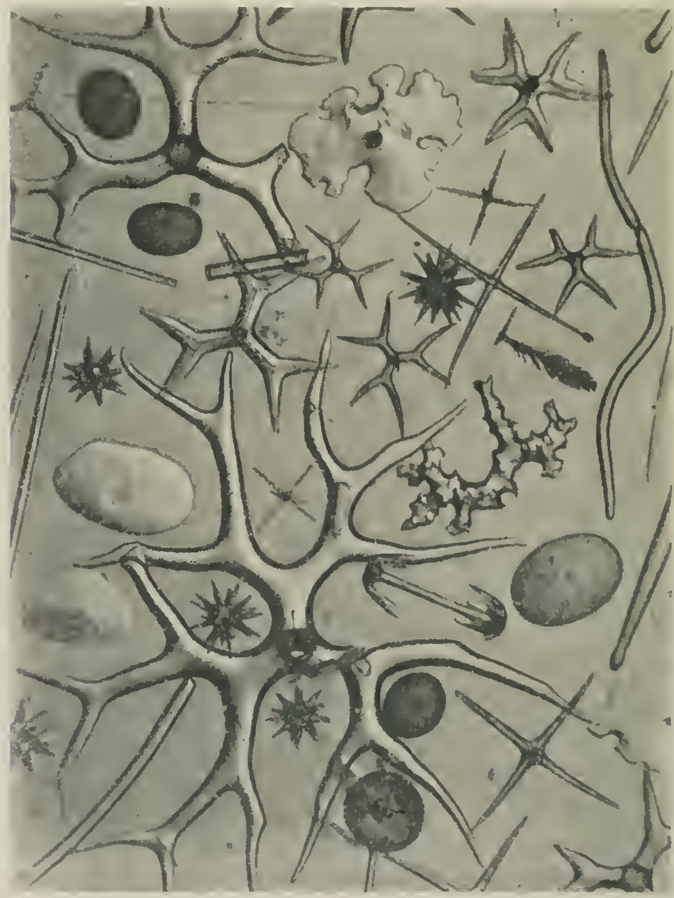

Fig. 60.—Sponge spicules from St. Peter, Hungary—greatly magnified.

few words so as to make one's meaning intelligible. However, if my reader can imagine a number of the simple amœbæ-organisms we first considered aggregated together and the mass traversed by canals opening from the exterior, and the whole supported and strengthened by horny, silicious, or calcareous

matter, then he will have some idea of what a sponge is. Through the canals and pores that traverse this community, passes a constant circulation of indriven water, from which source the various individuals obtain their food and air supply.

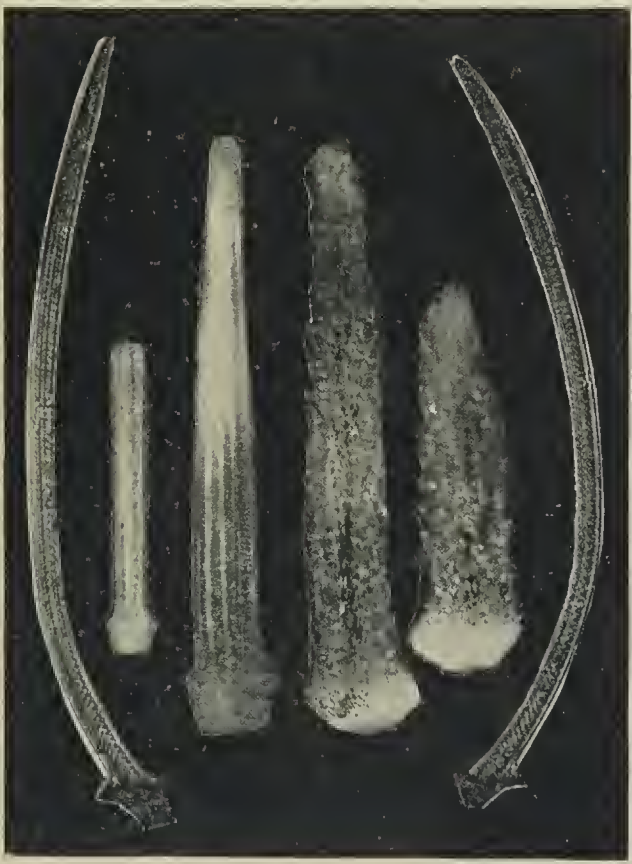

FIG. 61.—Spines of sea-urchins and star-fish—magnified. The forms with rough edges are from a star-fish.

These arrangements need not concern us here, however, other than that the whole arrangement, as previously remarked, is strengthened by silicious or calcareous spicula which are embedded one with another amongst the softer and fleshy parts, serving as a kind of chain-armour. These silicious

spicules, although so small as often to be invisible to the unaided eye, assume the most curious, fantastic, and beautiful forms, each species retaining its characteristic shape (Figs. 59 and 60). Of course all sponges are not like the familiar toilet article, this horny elastic skeleton being replaced in some

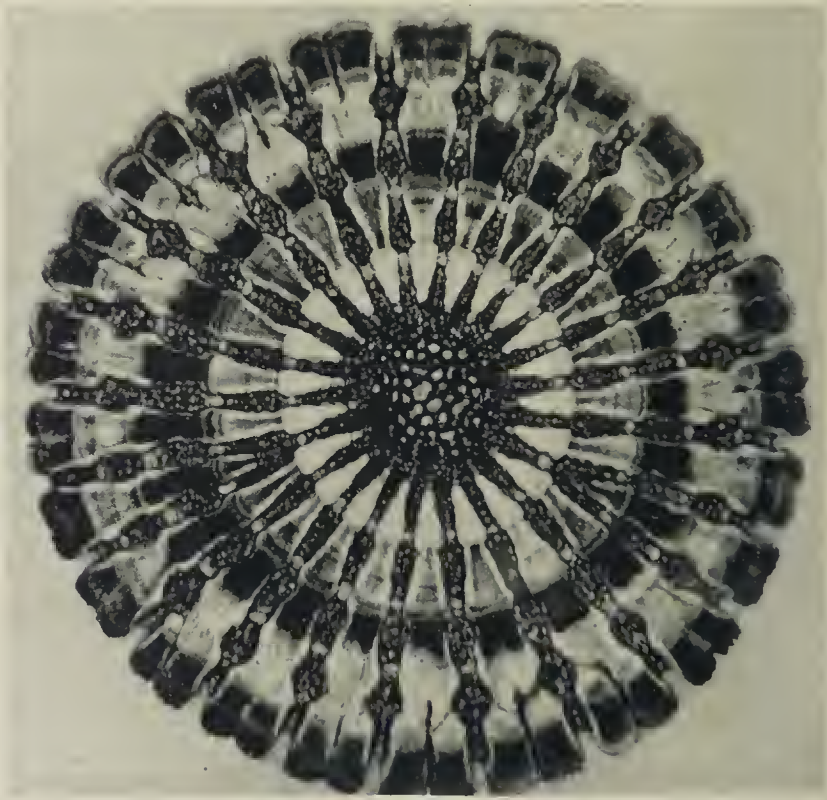

Fig. 62.—A transverse section of one of the spines of a sea-urchin, showing its internal structure—magnified.

species by solid, laminated, brittle silicious fibre, often assuming the form and appearance of fancy spun-glass vases familiarly known as "Venus' flower-baskets"; while apart from this class of skeleton we have the calcareous or carbonate-of-lime forms.

The sponges flourish on the ocean floor often at great depths, and are always absorbing and elaborating silica and carbonate of lime from the waters, and so adding to the ever-increasing quantities accumulated by the various life-forms we have previously glanced at. And if we look around at the numerous organisms that inhabit the shallows and depths of

Fig. 63.—A brittle-star—magnified about six diameters.

the ocean, it becomes apparent that the microscopic plants, animalcules, and the larger sponges are not by any means the only class of living things that possess this curious habit of gathering soluble lime and silica from the waters. There are many other strange creatures employed in like occupations, conspicuous amongst which are the wonderful and interesting

reef-building and other corals of the warmer seas, which, although but insignificant jelly-like organisms, can in some wonderful way secrete in vast quantities the form of carbonate of lime known familiarly as "coral," of which I shall have more to say later.

Still advancing in life-forms, the characteristic does not cease, for we have yet sea-urchins, star-fishes, and innumerable forms of shell-fish and crustaceans, all continuing the same peculiarity (Figs. 61, 62, and 63). Although as we reach still higher life-forms the characteristic becomes less prominent, yet even here it is interesting to observe that the hard parts of most animals, whether of land or water, consist of some compound of lime.

Nor is this process in the plant world confined to microscopic forms of life, there being a number of familiar algæ or seaweeds which absorb sufficient carbonate of lime to clothe completely their weak and delicate fronds, giving them a rigid and stony appearance. And so this strange habit seems to cling alike to plants and animals: even some considerably higher plants, such as grasses, horsetails, etc., show a decided tendency to develop silica in their tissues, although the lowly diatoms present this feature most conspicuously.

II

Having, then, glanced at the present lowly life-forms, we have now a few points to seek from the palæontologist concerning the simplest forms of life geologically considered. We find, for example, that the oldest known animal, or supposed animal life-form, was the *Eozöön*, or "dawn of life," which is recorded in the Laurentian rocks of Canada; and it is believed by those competent to judge—although others equally competent dispute the point—that certain layers of limestone there found alternating with other layers of green serpentine mineral are the fossil shell remains of a gigantic foraminifera. Whether this be of organic origin or otherwise need not, however, concern us here; sufficient is it that the earliest form of life in

the world is attributed to the same class of lowly organisms as those of the lowest life-forms of the present day, and one, moreover, possessing this curious habit of extracting the soluble carbonate of lime from the waters for the purpose of building its shell.

All through the Primary epoch, from these early lime-builders of the Laurentian period, if such they were, to the Cambrian, Silurian, Devonian, Carboniferous, and until the closing Permian system, we get an increasing development of low life-forms, similar in most respects to those lime-working organisms now living, at which we have glanced : lowly seaweeds, foraminifera, sponges, corals, sea-lilies—a kind of stalked star-fish—sea-urchins, shell-fish of all kinds, and huge crustaceans. Some of the Silurian foraminifera are apparently identical with existing forms. Even the first vertebrates seem to have made their advent as builders, these representing the curious armoured fishes, encased with bony plates or enamelled scales.

At the dawn of the Secondary epoch our lime-working organisms seem to have undergone troublesome times, many species becoming extinct. But though scarce in the Triassic system, the seas of the Jurassic period seem to have again attained those conditions essential to the life of the lower marine organisms, and at the close of this system they are again gaily continuing their important work.

In the next Cretaceous or chalk system the seas exhibited a marvellous display of foraminiferous and sponge growth, the latter characterized by flinty or silicious skeletons rather than calcareous, while corals, sea-urchins, star-fish, and crustaceans accompany these in increasing numbers. And so the Secondary epoch closes.

For our purpose we need not consider the life-forms of the Tertiary epoch, which marks the beginning of the present order of things, other than to remark that during the beginning of this period and the close of the Secondary epoch, foraminiferous life seems to attain its meridian, physiologically considered, in hundreds of generic forms, and numerically their abundance was such that thousands of miles of nummulitic limestone of

the Old World owe their origin to the accumulations of their calcareous coverings. The limestone formations of these periods are many hundred feet in thickness, and rival the limestone deposits of former geological periods, and the coral reefs of the present day. The orbitoidal limestone masses of the New World are likewise almost entirely the work of foraminifera; while extensive deposits of silica—for example "Tripoli" and other silicious earths—constitute the remains of the minute diatoms and radiolarians we have previously considered.

III

We have briefly viewed existing and past lowly life-forms, and shall now be better able to comprehend the magnitude of the work of even the most insignificant of Nature's creations. The lowly organisms that we have briefly considered from the minute protoplasmic speck to the higher and more complicated forms, possess, as we have seen, largely this wonderful power of extracting carbonate of lime and silica from the waters they inhabit, fulfilling this function in their own life-interests. Why one microscopic atom of vitality should appropriate lime, and another exactly similar organism silica, is one of those problems that science has yet to explain. However, it is by no chance-work that the habits of these creatures should so vary, for we know that many of our present land areas and rock formations were first begun and built up by these lowly plants and animals. And not only was this stupendous task performed in remote ages: the work has been in progress in every geological period, including the present. These lowly organisms are to-day as busy as ever they were, building up and restoring those rock formations which other forces of nature are equally destructive in breaking down (Fig. 64).

As the river flows along its course, and the storms beat against the rocks, the wear and rub carries them slowly away in solution to the sea, and it has been calculated that from twelve to fifteen thousand tons of limestone are daily so carried to the sea by the Thames alone. All rivers alike continue this

work of slow but sure destruction, as does the sea itself as it dashes its great waves against the coasts. Although this is an insignificant factor for the moment, in the course of time it becomes exceedingly important, and, unless some means of reconstruction intervened, the solids of the globe would eventually become destroyed as such. Nature, however, is the theatre of incessant change, and when solid matter is disintegrated it

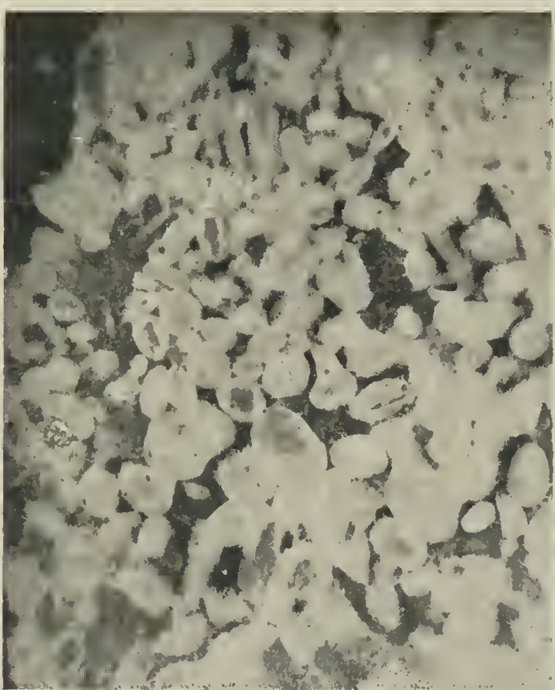

FIG. 64.—A magnified section of limestone, showing how it is built up of foraminiferous shells.

is only to rearrange it and build it up in another form—nothing is irretrievably destroyed; and so this continual dribble of lime and silicia from the accumulating skeletons or shells of these calcareous and silicious organisms becomes the potent agent of reconstruction.

Huxley has estimated that if the total thickness of the deposit of solid matter on the bottom of the Atlantic or Pacific

oceans, formed by the foraminiferal shower, is as much as one-tenth of an inch in a year, and if these oceans have existed for only one hundred thousand years—which time geologically considered is an exceedingly small period—this apparently unimportant operation will have sufficed to cover their floors with a limestone bed no less than 800 feet thick.

So that if, by any of those movements or upheavals so familiar in geological history, the present oceans were raised and became dry land, vast beds of softish limestone built up by foraminifera, star-fish, sea-urchins, shell-fish, and similar animals, with large or small quantities of silex added by the deposits of diatoms, radiolarians, sponge-skeletons and spicules, would be added to the earth's dominions.

Hardly a reference need be made to the Great Barrier Reef protecting the north-east coast of Australia, running with only a few breaches in its continuity for some 1250 miles, with an average breadth of thirty miles, the sea outside of it in some places showing a depth of 1800 feet; and this but represents the colossal work of the coral-producing polypes.

If we compare with this great coral reef the enormous distribution of the nummulitic limestone over the earth's surface, stretching from the west of Europe to the frontiers of China, we can only marvel to think how such wondrous formations should take their origin from such insignificant causes.

In a like manner, although not in such extensive areas, large beds of silicious deposits are found, in some places as a soft, friable rock, such as "Tripoli," while in others it appears as a hard slate known as "polishing slate." Chemically, it consists of almost pure silica, and the stratum is often from fourteen to twenty feet in thickness. Such deposits are found in various parts of the earth, and are but the remains of the lowly diatoms of which I have previously spoken, once gaily swimming the waters of the lake or sea of which their remains denote the previous existence.

Surely, then, Nature is one great whole; we have but to glance at the vast changes that have taken place on the earth to realize how very much these affect the present life. Lowly organisms prepare and organize matter for the higher life-forms that are to follow. Particular life-forms predominate over others for long periods together, after which they are slowly but surely displaced, and gradually an entirely new form, fulfilling perhaps quite other functions, arises. Why should these changes occur in what was apparently an evenly-working life-scheme? Was the earth being prepared for its highest creation, man, and a wise and all-seeing Creator directing and guiding these life-seasons to benefit and serve this highest form of creation?

In conclusion, let us briefly glance at one or two prominent examples of past life, and see what they reply to our queries. The carboniferous era produced enormous quantities of vegetation such as the earth had never seen before, or has witnessed since. These vast, dense, rapidly-growing marshy forests sprang up at that period and grew abundantly, for *apparently no other reason than that the climate was congenial to their production. These forests to-day constitute one of the greatest sources of wealth and happiness to humanity, and probably will serve as such for many future ages*, for, as every one knows, the vast stores of our mineral coal are due to the fossilized remains of the carboniferous forests.

And again, those various geological deposits, such as chalk, limestones, clay, slates, etc., etc., are all indispensable to man in preparing his abodes. To these we have to add the valuable and useful minerals originating in such deposits, which are but other ripened fruits the earth has prepared.

Finally, then, as we take a "bird's-eye view" of some of the prominent features of our planet's history, and its inorganic products in relation with its life-forms past and present, we trace no break in the work of Nature; every living thing is provided with the wherewithal to support its life and build its home, although the material for the same may have been

organized ages before its advent. And so science reveals a unity of purpose in the whole long course of Nature's stupendous processes; and the minutest living organism shows the same comparative beauty and perfection as the grandeur of the united whole.

CHAPTER V

The Life Story of a Hover-fly (*Catabomba pyrastri*)

PROBABLY everybody who visits a flower garden from early summer until late autumn observes at one time or another some of the numerous species of hover-flies—curious flies which remain poised over flowers by means of the rapid vibrations of their wings, and are often mistaken for wasps owing to their bodies being similarly banded with yellow and black. Not infrequently, indeed, this resemblance to their sting-protected neighbours causes them to be carefully avoided, although they are, in fact, quite harmless.

Even if the garden is only a few square yards in area, and whether it lies at the back or front of the house, provided there are flowers in bloom and the weather is sunny, you are sure to find some of these hover-flies; most probably several species, differing in size and arrangement of colour bandings. For the smaller kinds are not younger examples of the larger forms, as one might at first imagine, but entirely different species; small flies do not grow into larger ones, their full growth being attained when they reach the winged state.

One of the largest and commonest of these insects amongst British species is shown in illustration Fig. 65, while feeding on pollen from a poppy-bloom. It is the life story of an individual of this particular species that I propose to relate here, from the moment it leaves its minute and beautiful egg until it acquires its transparent wings, which sustain it in almost motionless poise above the flower-blooms, and, should

you attempt to touch the insect, convey it away with such extraordinary rapidity that you rarely know in which direction the fly has escaped.

However, before making further reference to this insect, I want to anticipate what I have to say about the hover-fly by

Fig. 65.—The hover-fly feeding on pollen from a poppy-bloom.

reminding you of some other less-inviting insects, which you will have often regretfully noticed on many of your choice plants, known as aphides, or green-fly, or, more familiarly, as "blight." The destructive ravages of the various species of these insects, and the rapid manner in which they multiply, are but too well known to flower growers.

It may not at first be apparent what connection the aphides, or green-fly, have with the hover-fly whose life story I have here to tell, but, for the moment, I must ask my reader to be content with the information that hover-flies are among the most destructive enemies with which aphides have to contend. And, strange as it may seem, although these flies are continually dealing death to the aphides at the rate of many hundreds per hour, yet you never see a fly touch or injure a single aphis; not even if you watch it morning, noon, and night will you detect it in the act. It spends its whole time, when not resting, in swiftly flying from plant to plant, sometimes alighting upon their leaves, but more often upon their flowers, to feed on the pollen and nectar they so abundantly provide.

If we watch one of these flies when poised almost motionless above a plant, we see it suddenly drop in almost hawk-like fashion, generally upon a flower whose bright petals seem to have a particular fascination for it. While we saw it poised above, it was only waiting an opportune moment of paying its visit when the way was clear of bees and the throng of other insects all so busy beneath it. After it has taken its fill of nectar and pollen it rises again, and, if our eyes are quick enough to follow its sudden manœuvre, we find it almost instantly several yards away, once more poised above another plant. This time it is evidently not attracted by flower-bloom, for it is hovering above the green foliage of a chrysanthemum, whose flowers have yet to develop.

Down it swoops again, upon a leaf this time, and then, after arranging its toilet for a minute or two, it quietly disappears beneath the leaf. After a brief time it comes to the upper surface again, and then once more with a lightning-like movement it has gone—we know not where; but mark that leaf on which we saw it settle, for it has a story to tell.

The Egg

We carefully examine the leaf, and amongst the closely arranged hairs on its under side we find a tiny white speck

which we have to place beneath a microscope to properly appreciate. There it becomes a beautiful object indeed, for although it is really only about one-thirtieth of an inch in length, yet it is of a delicate pearly hue, studded with very minute raised points, which, attracting the light, produce a charming effect. In shape it is oblong, tapering at its ends, and lies on one side. In illustration Fig. 66 I have shown

FIG. 66.—A magnified view of the egg of the hover-fly, which is in actual size about one-thirtieth of an inch in length.

it photographed through the microscope; such is the wonderful egg which our hover-fly placed beneath the leaf.

These eggs are deposited about the leaves of numerous kinds of plants by the mother insect, both on upper and under sides of the leaves, the only condition being that aphides infest the plant. And when we look closely at our chrysanthemum branch we find on several of its topmost shoots a sprinkling of these green-fly. Here, then, we have the first stage in the life history of our hover-fly.

The Larva or Grub

Three days later the shell at one end of this tiny and beautiful egg bursts open, and from the opening emerges a minute white grub. I was fortunate in happening to look at the egg just when the grub was halfway out, and so was able to watch its first movements. During the three days that the egg had been laid, the few aphides we noticed had multiplied in that rapid and extraordinary manner characteristic of these organisms—of which more anon—and were now abundant.

The young hover-fly grub after it emerged from the egg was, when fully extended, about one-sixteenth of an inch in length, and moved about amongst the hairs of the leaf at a moderately rapid pace for a newly hatched grub. Eventually it reached the central vein, or midrib, of the leaf. Here it almost immediately came in contact with the extended leg of a full-grown aphis which was quietly feeding, and into this leg it at once plunged its three-pronged beak, or trident. However, the aphis was too strong for its assailant, and pulled it all about the leaf in an endeavour to free the leg. Still, the grub did not loose its hold, and at last got firmly attached to the leaf by its tail end, and, although the aphis still pulled and struggled, its efforts were of no avail. Through my magnifying lens I could plainly see that the grub was making a good meal from the juices of its victim's leg, although it was working hard for its dinner, owing to the large size of its prey.

After the larva had appeased its first appetite somewhat, it gave in to the struggles of its victim and let it go, and then proceeded to move leisurely along the vein of the leaf, its pointed head continually extended hither and thither in every direction. Presently, while making these thrusts into the surrounding atmosphere, it happened to touch another aphis, and immediately these movements ceased; then, before I hardly realized what had taken place, the grub had whipped up the aphis—which was a young one—from the leaf in a most business-like fashion, catching it by the back of the head and holding it well away from the leaf, so that its wriggling legs

could not get a hold. In this way it had the aphis completely under control, and so held it in the air while sucking its juices. About three parts of an hour later it cast aside the shrunken skin of the aphis, just as we might the rind of an orange.

In illustration Fig. 67 is a novel microscopic photograph of the grub while engaged upon this meal. It is magnified about twenty diameters, but the extent of the magnification can best be judged by thinking of a tiny aphis and the minute hairs on

FIG. 67.—The young hover-fly grub sucking the juices of its captured aphis—magnified about twenty diameters.

the under side of a chrysanthemum leaf as they appear to the unaided sight and then looking at the illustration. After the grub had sucked dry this aphis it took a rest for about an hour, and then proceeded on another hunt for prey. Before long it was again performing tactics similar to those I have described above.

During the first day of its existence it sucked dry three aphides, without counting its preliminary taste of the leg of a

fourth. The following day it ate at least twice that number; and for ten days it pursued its destructive path amongst the aphides, its appetite ever increasing as time went on. As the grub gets older it becomes of a green colour, with a white or pale yellow stripe running from its pointed head to its tail end, and these colours harmonize so well with the leaves and the

Fig. 68.—A full-grown hover-fly grub—natural size.

prey it seeks that it becomes very inconspicuous amongst its surroundings. In illustration Fig. 68 is shown a full-grown grub of natural size.

It is quite an entertainment to watch one of these full-grown grubs prowling about and capturing its prey. I will endeavour to explain its methods of procedure, and illustrate

my remarks by means of actual photographs of the grub while so occupied.

In the first place it is interesting to observe that although this grub has to seek and capture aphides, yet it is both blind and footless. Its method of locomotion is curious. It can adhere firmly by the rough edges of the under side of its body, and to move forward it stretches out its head—which is not distinctly marked, being simply a tapering proboscis or fore-

FIG. 69.—The large grub has just speared an aphis from beneath the leaf-stalk.

part carrying a mouth provided with a trident or aphis fork, by means of which it spears its prey—as far as it can reach, and then digs in its trident, at the same time loosing at its hinder parts and bringing them up, presenting the appearance of being about to turn a somersault, but just as you expect to see this manœuvre, out stretches its head again, and so it moves along in this loop-by-loop fashion. I placed one grub on a sloping sheet of glass to test if it really used its trident for digging into

the leaf when moving about, but it made very poor progress, continually rolling down the glass.

In this way, then, it travels about the leaves and branches, and between its loops—while stretching itself out—it waves its head from side to side, making thrusts here, there, and everywhere, for, being blind, it has no idea where its prey is to be found; and if no aphides lie within its reach another loop is made and more thrusts around, and so on until a victim is captured.

FIG. 70.—The grub has here withdrawn its head with the aphis speared upon its trident.

In illustration Fig. 69 is given a slightly enlarged view of two grubs while seeking prey; the lowermost and largest is full-grown, while the one above it is about half-grown. The full-grown example, it will be seen, has speared an aphis from underneath the leaf-stalk; and in Fig. 70 it has withdrawn its head with its victim—which appears as a black spot on the tip of the grub's nose—on its trident. However, it was not in a comfortable position to enjoy its meal, for these grubs always

lift their prey with wonderful celerity clear of the leaf or branch on which they find them, and, while standing on nothing but the tail ends of their bodies, suck the juices of their victims, keeping themselves rigid and the prey hoisted in the air until nothing is left but its empty skin, which is then quickly thrown on one side. In this case the grub looped itself clear of the axil of the leaf to a more open space, and

Fig. 71.—The grub in the act of extending its body before sucking the juices of the aphis.

there it immediately assumed its characteristic attitude when devouring its prey.

In illustration Fig. 71 it is shown at the moment of stretching itself out, and in Fig. 72 again, a second later, when fully extended and sucking its victim's juices. It should, of course, be remembered that the whole of the movements illustrated in Figs. 69, 70, 71, and 72 are only the work of a few seconds. The movements of the half-grown grub should

also be observed; note how carefully during this short period of time it is searching the branch for food.

Another interesting example is illustrated in Fig. 73, where a grub is seen fully extended with an aphis on the point of its nose. It will be understood by comparing this latter example with the previous one, that the grubs do not extend their bodies in any one regular direction to consume their prey, but generally select the nearest most open space in which they can

FIG. 72.—The grub standing on its tail in its characteristic fashion, holding its body rigid and clear of the branch, with its prey on the end of its nose.

stretch out to enjoy their meal free from surrounding leaves and the mass of aphides beneath them.

From what we have seen it is obvious that the hover-fly grub is one of the best friends that the gardener has, and he should do all in his power to encourage the parent insects by cultivating those flowers on which they like to feed, such as poppies, cornflowers, sweet-sultans, and other compositæ or daisy-like flowers—for, as we have previously observed, when

the hover-fly attains its winged state it no longer feeds on aphides.

How effectually these grubs carry on their destructive work amongst the aphides can be readily demonstrated by placing a nearly full-grown grub on a house plant that is thickly infested with these insects, when, in the course of a few hours, probably not a single aphis will be left, although their shrunken skins will be in considerable evidence.

FIG. 73.—Another grub fully extended with an aphis on the point of its nose.

Man's insecticides and fumigating devices sink into insignificance beside the persistent onslaughts of these hover-fly grubs, of which there are many common British species besides the one considered here, that work similar havoc amongst aphides. For this is Nature's own method of keeping one organism in check by means of another. Of course, there are other insect grubs which co-operate in this same work, such as those of the familiar red and black-spotted ladybird-beetles and those of the handsome lacewing-flies, but the hover-flies

probably outrival all their compeers in this respect; especially does this apply to the particular species considered here, for it is one of the largest and develops into a grub a good half-inch in length, and when full grown it has a most astonishing appetite.

Réaumur has estimated that a single aphis may be progenitor to no fewer than 5,904,900,000 individuals during the few weeks of its life. Even in one day an aphis may produce twenty or more young, all females like herself, which grow to full size at an astonishing rate, and then immediately begin themselves to bud out young, again all females, and these grandchildren are soon budding again. This method of budding reproduction has been shown to continue as far as the twentieth generation, no males appearing until the late autumn broods; from these late broods eggs are produced which carry the species through the winter, and these again in the spring produce the first brood of the budding females.

With such marvellous reproductive resources one can readily understand how the few aphides seen one day on a plant become a multitude a day or so afterwards. The hover-fly, too, is well acquainted with this state of affairs, and probably while it poises above the plants on its rapidly vibrating wings its large eye-masses observe amongst the young shoots the few tiny aphides, and then with remarkable instinct it carefully places one or more of its minute and pretty eggs in their near vicinity, apparently with a perfect knowledge that in the course of the three days that its eggs are maturing ample provision will be forthcoming to supply the ever-increasing appetite of its hungry offspring.

After the eggs are deposited it is only a matter of time with the aphides—a time which depends on the number of eggs deposited by the hover-flies; not to mention those of the lady-bird-beetles and lacewing-flies. The first day's meal of the hover-fly grub may consist of three aphides, as we have seen, but the nature of its appetite for the last few days of the nine or ten of its existence as a grub is something to delight the heart of the gardener, for aphides disappear as if by magic.

From an estimate I made with a number of full-grown grubs I found that the average rate at which they sucked aphides dry was about one hundred per hour each grub. Of course, they have to rest occasionally, but, being blind, night is as good as day to them, so that even allowing half the twenty-four hours for resting, which would probably be a considerable over-estimate, each full-grown grub would dispose of more than twelve hundred aphides per day. Such is one of the means by which Nature checkmates the rapid increase of the aphides.

The Pupa or Chrysalis

At the end of ten days or thereabouts, however, this awful appetite of the grub declines; in short, it turns sick at the

Fig. 74.—The pear-shaped pupa or chrysalis of the hover-fly, hanging among the leaves.

sight of aphides, and should any be placed in its way it turns abruptly from them and selects another path, so loathsome have they become. And then it wanders restlessly about the

leaves and branches, at last coming to rest in some quiet spot beneath a leaf, or amongst a cluster of leaves. Here it puts away its trident or aphis spear for ever; or perhaps the last purpose served by this organ is to assist in attaching the grub to the leaf, for it is by that end that it at first secures itself.

Adhering firmly to the leaf, the hind and broader parts of its body are drawn up until the grub becomes somewhat pear-shaped. Its green colour and white band then slowly disappear and give place to a golden-brown hue, its skin at the same time hardening until it becomes of a horny consistency. Such is its pupa or chrysalis, which differs from those of butterflies and moths in that the larva or grub does not moult its skin before becoming a pupa. In this case we have seen that the actual skin of the grub is changed into the pupa or chrysalis shell. In Fig. 74 the pupa is shown hanging amongst the leaves near the central part of the chrysanthemum branch on which it hunted its prey.

The Perfect Hover-Fly

Ten days later this golden-brown pupa splits and a large piece of the shell breaks away, and through the opening the shining blue-black hover-fly, with the three interrupted cream-coloured bands across its abdomen (Fig. 75) appears, trim and ready for further service to the gardener by carrying pollen from flower to flower, and so assisting in fertilizing them, and then again, in the case of the female insect, by depositing her tiny eggs with all their potent possibilities amongst his plants.

Fig. 75.—The perfect hover-fly—natural size.

Thus the development of this species of hover-fly occupies

a little over three weeks, and then it is able to reproduce its kind, which allows of several broods appearing during the course of the summer. This also explains why these flies are most abundant during the autumn months.

There is one point in the life history of this insect, however, which I have not been able to clear up either by observation or inquiry—namely, how it tides over the winter. Does an occasional fertilized fly hide away in some sheltered nook, like the familiar wasp, and deposit the first eggs of the summer brood? Or do both male and female insects live through winter and breed in the early spring, like some of our familiar butterflies? Or are eggs deposited within the scales of buds, or similar situations, like those of its prey the aphides? Or, again, does its pupa, like that of the orange-tip butterfly, remain attached to stalks and stems throughout the rains, frosts, and snows of winter and spring? Of course, it is possible for the grub to hibernate as many caterpillars do, but this, I think, is probably the least likely solution, while, perhaps, one of the first two suggestions is most probable.

CHAPTER VI

The Life Story of the Jelly-fish

EVERYBODY who visits the seashore is familiar with those curious expanding and contracting lumps of jelly-like substance of various sizes which, from the side of a boat or a landing-stage, may be seen to slowly rise from the depths and, for a time, with a peculiar waving movement, steer their course near the surface; then, just as quietly they sink again beneath the water, down, down, down, until they are completely lost to view. Or, even on the sand, some of these umbrella-shaped masses of jelly-like material may be found, cast ashore and helpless. And, of course, "everybody" knows, and will probably tell you, if questioned, that these are jelly-fish. If, however, we ask, what is a jelly-fish? we usually find how limited is the information that "everybody" possesses, and that, familiar as these organisms are, we experience considerable difficulty in getting beyond the point that a jelly-fish is—a jelly-fish.

If we were to ask, what is a butterfly? or, what is a horse? instead of what is a jelly-fish? everybody would probably be able to add a measure of information that would serve to define the animal in some degree. Why, then, is there such a general ignorance about so familiar an organism as a jelly-fish.

Perhaps the best reason why the great mass of ordinary observers cannot give an intelligent definition of a jelly-fish may be found in the fact that these organisms often have a very complicated life history; in fact, the greater number of this class of

animals are really not individual organisms at all, but only a part, or a stage in the life of the original animal. Moreover, if you were to see the parent organism, together with the off-

Fig. 76.—The parent of a jelly-fish, often mistaken for a seaweed.

spring, you might be disposed to ridicule the idea of any connection between them. You might even point out that the suggested parent animal was not an animal at all, but a

familiar sea-weed which is often found growing on shells and stones (illustration Fig. 76), and is to be frequently seen in private houses, in vases, where it serves a decorative purpose. Since, then, an organism which we may have always regarded as a sea-weed, may be the parent of a jelly-fish, it will prove interesting to trace the connection between these unlike organisms, and, at the same time, the process will help us to understand what a jelly-fish really is.

FIG. 77.—The hydra, or fresh-water polype, commencing to extend its tentacles.

I want you first, however, to leave the seashore and come with me to a pond, the surface of which is covered with a flat film of the familiar green, disc-like fronds or leaves of duck-weed. Some of these green plants we drag in to shore by means of our walking-stick, and these we place with some of the pond water in a glass vessel we have brought for the purpose. Then we put the vessel against a well-lighted window. In due course, if we watch the pendent roots of the

duck-weed, we shall probably be rewarded for our trouble by observing that some little green knobs which are borne by the roots begin to elongate and perform some strange movements. At first they are very tiny, and require a pocket-lens to observe them clearly, but, later, they begin to develop into star-like bodies, a circle of short tentacles begins to appear at the free end, and these tentacles elongate until the organism is about a quarter of an inch in length. In illustrations Figs. 77 and

FIG. 78.—The hydra a moment later, with tentacles extended.

78, enlarged views of one of these tiny animals is shown while this elongation of the tentacles is taking place.

This curious little animal, which is common in most ponds where duck-weed is plentiful, is known as the Hydra or Fresh-water Polype. It extends its tentacles in this manner in search of water-fleas and small animalcules, which form its food. When the prey comes into contact with one of these waving tentacles, it is stung by very minute poisoned darts, groups of which are arranged about these organs. In this way the prey is paralyzed, becomes inactive and is easily secured, the other

tentacles promptly assisting to convey it to the mouth of the organism, which occupies a central position amongst them all. Such, then, is the curious little green hydra when feeding, but at the slightest alarm it withdraws its extended tentacles and becomes again a tiny green knob, just as we first saw it. But what has all this to do with jelly-fish? I imagine my readers will ask. I must, however, beg for just a little more patience on their part, for when we understand a few points about the methods of feeding and of reproduction of the common fresh-water hydra, we shall have learnt a great deal relating to the habits of the parent animals of those curious organisms we call jelly-fish.

Reproduction in the hydra is effected in two different ways. During the autumn eggs are produced which rest amidst the mud during the winter and develop into hydræ in early spring. In the summer, however, when food is plentiful, a budding process takes place. A little swelling arises on some part of the body of a hydra and gradually develops until it has tentacles like its parent, whereupon it becomes detached, and starts life on its own account.

Having, then, seen so far into the life history of the hydra, we may now turn again to those horny "sea-weeds" so useful for decorative purposes (Fig. 76). As we shall presently see, these are not sea-weeds at all, nor do they even belong to the vegetable kingdom; hence they must be animals.

Let us take just a tiny portion of one of the delicate branches of this familiar "sea-weed" and place it beneath a microscope; Fig. 79 represents what we see. We observe that the branches are constructed of a flexible, horny substance, and that, arranged along their whole length (in this particular species) are numerous little cups set opposite each other. There are also occasional larger capsule-like objects containing rounded bodies, but these, for the moment, we may disregard.

Now, these horny branches represent the homes of innumerable little organisms, for in each of the tiny cups on opposite sides at one time lived a little animal which, in all essential points of structure, was exactly like the little hydra we captured

from the pond. In short, these brown moss-like or seed-weed-like structures are really the skeleton remains of a colony of tiny hydrae or polypes. And from each little cup a minute polype once put forth its delicate tentacles to search the surrounding water for still smaller prey, the poisoned stinging threads of its tentacles paralyzing tiny animalcules and making their capture easy; in short, the feeding process was just the same as we have seen the fresh-water hydra carrying on. In fact, the whole of the organism is merely a collection of hydræ which only differ from their fresh-water relative in that the new hydræ when they bud out, instead of becoming detached, remain permanently united, and so build up a common branch, the body cavity of every individual organism opening into the central or main branch, and in this way a connection is kept up amongst them. Finally, the whole colony is protected by the horny sheath, to the building of which each polype has contributed its little share.

Many and varied are the forms of these pretty zoophytes or animal-plants, which we are so apt to call "sea-weeds" or "sea-mosses," found on every seashore, and in Fig. 80 another example is shown. Here, however, we have not the horny skeleton alone, for we see the tiny polypes all busy with extended tentacles seeking their prey; while near the top a new polype is seen just developing in bud-like fashion.

We now see the connection between the little fresh-water hydra and the zoophytes, or "sea-weeds" as we familiarly know them. But what connection have any of them with jelly-fish? I fancy I still hear my reader asking. Well, that is a query I am just about to answer. And to do so I must call your attention to the two capsules seen in Fig. 79. You will note that at the apex of each a tiny lid opens, and that through the transparent walls can be seen minute rounded bodies.

These capsule-like objects are modified buds of the zoophyte colony, and their ultimate function is to produce eggs, which the ordinary hydra individuals are unable to do. Glancing also at Fig. 81, where an older portion of a branch from the same

species as that illustrated in Fig. 80 is shown, we see amongst the ordinary tentacled individuals of the colony some similar capsules which likewise contain rounded objects. Now we are particularly concerned for the moment with these capsules

FIG. 79.—A tiny portion of the branches of the organism, or "seaweed," shown in Fig. 76, magnified to reveal its structure.

and their contents, for, when a capsule opens and one of the enclosed organisms escapes, a tiny medusa or jelly-fish is born.

Still keeping to the example illustrated in Figs. 80 and 81, we will examine, by means of the microscope, one of the minute jelly-fish which is born from the special buds of this

particular zoophyte or plant-like animal. In Fig. 82 I have shown a magnified photograph of one of these medusæ.

The little organism might be compared in general shape to an umbrella with a short thickened handle. This handle-like

Fig. 80.—A branch of a tiny zoophyte, or hydra colony, with the polypes, extending their tentacles in search of prey—magnified.

portion is the little polype which is suspended from its jelly-like bell or umbrella. The mouth of the organism is situated at the end of this handle; the stomach is at the opposite end, and from it four tubes can be seen radiating; these tubes are

connected with the canal which runs round the edge of the umbrella. Two other points we should also notice; first, that about midway on each of the four radiating tubes a dark spot appears, each of these spots representing an ovary in which

FIG. 81.—An older portion of the zoophyte shown in Fig. 80, bearing capsules as well as polypes.

eggs would eventually be produced; and secondly, that around the edges of the disc or umbrella are numerous tentacles.

When the jelly-fish is liberated, it is very active and leads an independent life, capturing its food from the surrounding

waters by means of its stinging tentacles. It soon begins to grow out of all proportion with the parent organism, and in a short time becomes a beautiful and delicate jelly-like organism, perhaps many times the size of even the whole colony of branches bearing the minute buds from which, as well as other tiny organisms like itself, it sprang to independent life. Then, as we

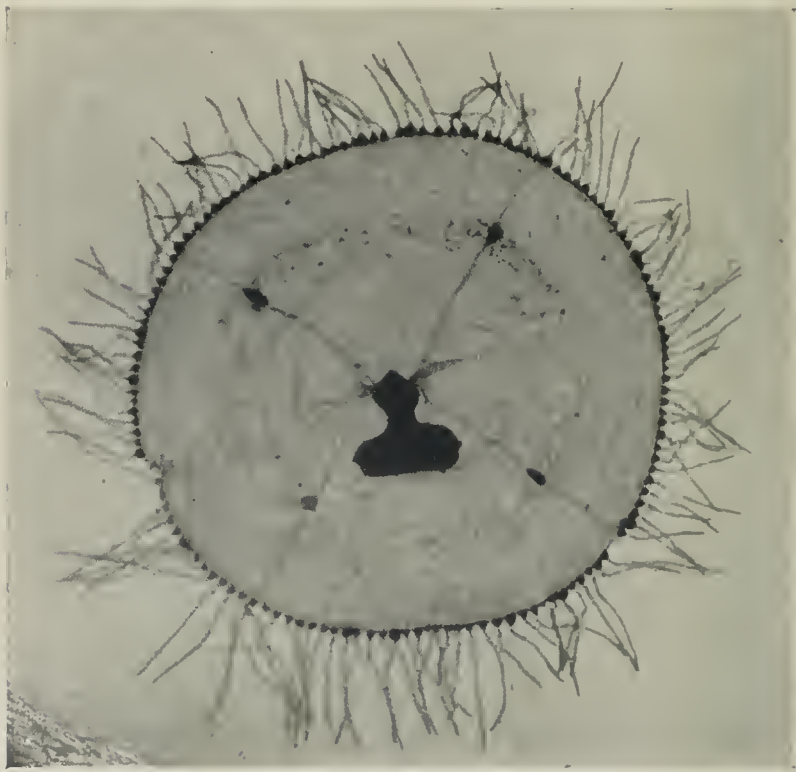

FIG. 82.—A magnified view of one of the minute jelly-fish born from the capsules shown in Fig. 81.

gaze at its transparent bell, and delicate fringe, pulsating through the water, we call it a jelly-fish; although, as we now see, it is really not a fish at all, but simply an organism developed from a tiny animal-plant or zoophyte.

I might have called this organism the offspring of the zoophyte, but, as we have seen, this free-swimming progeny

is altogether unlike the fixed and plant-like parent; and in truth, it is but a preliminary stage in the development of the eggs which shall finally produce the true offspring; but more on this point anon.

In a similar manner to that above described, most of the jelly-fish, with which we are familiar on our coasts, have been produced, although there are many curious modifications of the process. Some zoophytes, for instance, instead of setting free little jelly-fish from their capsules, detach those special buds wholly as free-swimming medusæ or jelly-fish, while others develop similar jelly-fish but do not allow them to wander, keeping them always attached, thus producing what looks like a jelly-fish plant. Other examples split their little hydra-like forms into a number of transverse sections, each tiny segment then swimming away to develop into a jelly-fish, often becoming of a gigantic size when compared with the parent hydra. Truth, indeed, becomes stranger than fiction when we study these curious animals. There is, for example, the Venomous Cyanæa, that giant jelly-fish often measuring, four, five, and it may be seven feet across its disc or umbrella, whose stinging tentacles, known only too well by bathers and fishermen alike, may exceed fifty feet in length. The victims who become entangled in the envenomed threads of this monster of the deep would not be consoled by a knowledge of the fact that this gigantic creature owed its origin to a little hydra not more than half an inch in height; such, however, is the fact.

Some large forms of these organisms are modified in another way, namely, by suppressing a stage in their life cycle, never having any fixed or zoophyte stage. In Fig. 83 an example of still another variation is illustrated. In this instance the jelly-fish stage is suppressed, no special buds for egg-development being produced, neither does the hydra branch into a zoophyte but remains a single hydra-like animal, attaching itself, usually upside down, to sea-weeds by means of a sucker at its foot, and resembling a beautiful convolvulus flower. The mouth of this apparent blossom is surrounded by eight groups of tentacles which capture unwary denizens

of the deep as prey. When this hydra finds food scarce, or wants to scatter its eggs in quarters best suited to their development, it looses its hold of the sea-weed to which it is attached, and becomes a kind of jelly-fish, swimming rapidly by means of alternate dilations and contractions of its umbrella,

FIG. 83.—A jelly-fish that is either a hydra or a jelly-fish at its will. Here it is shown in its hydra form (see Fig. 84).

and when spread out assumes the form shown in Fig. 84. In this latter illustration the eggs of the organism can be seen.

Now it only remains to determine what is the function of the many and varied forms of these strange organisms, also how zoophytes or animal-plants come to exist at all if their offspring become jelly-fish. These are the points we have finally to consider.

The jelly-fish, as we have seen, is a specialized individual of the zoophyte community, and the function it serves is to produce eggs. In due course, as the jelly-fish develops, sexual elements appear, and towards autumn eggs are produced, the

FIG. 84.—The hydra, shown in Fig. 83, in its jelly-fish attitude. Observe the numerous eggs.

free-swimming life naturally assisting greatly in their dispersion. The eggs also are provided with vibrating hair-like cilia, which convey them through the water. The remarkable feature, however, is that the eggs of the jelly-fish do not develop jelly-fish, but after settling in a suitable situation become tiny

hydræ, which either commence to bud out into one of the horny zoophytes or "sea-weeds," similar to those we have glanced at, or remain single animals, according to the habits of the particular species. In this way we get an alternation of generations, the progeny of the fixed or zoophyte stage is the jelly-fish, while the offspring of the jelly-fish is the fixed hydra or zoophyte. Such is the relationship between the horny "sea-weeds" or zoophytes and the strange organisms we know as jelly-fish.

Although the delicate, pulsating, semi-transparent spheres or bells of these animals are more or less colourless during daylight, yet at night they are endowed with some mysterious energy, the tiny and greater forms alike becoming living globes of light, giving a luminous and iridescent glory to the surrounding waters. This phosphorescence remains even with disintegrated portions of the dead bodies of these organisms.

Regarding their anatomy, traces of a nervous system, muscles, eyes, and probably organs of hearing are found in these glassy bells, and yet, notwithstanding their mysterious light-producing properties, their delicate sensitiveness, their stinging and poisoning capabilities, their locomotive powers, their translucent and graceful beauty, and their power to reproduce the ova that will develop the likeness of the parent zoophyte again, they are built up almost wholly of water. Agassiz gives an instance of a large example of the Venomous Cyanæa, previously referred to, which weighed thirty-four pounds, and would measure about seven feet across its disc, that was left to dry in the sun for a few days, and finally lost 99-100ths of its original weight. So that these remarkable animals, when the water of which they are so largely built drains and evaporates from them, leave but a stain to record the mysteries of the life with which they were once endowed.

To recapitulate, then. The familiar decorative "sea-weed" is not a sea-weed, but a colonial animal or zoophyte composed of numerous hydræ individuals, and the life cycle of the zoophyte consists of a fixed and a free-swimming stage; in the latter we recognize it as a jelly-fish. This jelly-fish stage has

probably been evolved as a means whereby, during the summer season, eggs could be more readily conveyed to those quarters most favourable to their future development. As winter approaches and food gets scarce, the jelly-fish lay their tiny ciliated eggs. The latter eventually settle down in the depths, well out of the way of danger from winter storms, to develop into a new zoophyte, which requires but little food material. Later, however, when the all-important egg-producing period comes round again, and food is once more plentiful, the hungry jelly-fish go forth to collect that which will best nourish the developing eggs.

Such is the wonderful story of the zoophyte and the jelly-fish; and when we see how marvellously these organisms of the deep have been provided for, surely we may with the poet sing—

> "How sweet to muse upon the skill display'd
> (Infinite skill!) in all that He hath made,
> To trace in Nature's most minute design
> The signature and stamp of power divine."
>
> *Cowper.*

CHAPTER VII

The Life Story of the Brimstone Butterfly (*Gonopteryx rhamni*)

IT is a bright sunny day in March or early April, and we are out for a ramble amongst the lanes and fields, when suddenly our eyes are attracted towards a butterfly of daffodil-like hue, which sails along with a swinging flight, as if it could not afford to waste a moment of the glorious sunshine that gives such brilliancy to its golden colour. But, as we watch it, we see it drop quickly down, and we cautiously approach the spot where it disappeared. But a careful search on all sides reveals no trace of our brimstone butterfly (for such it is), and, just as we have given it up as lost, and consequently become less cautious in our movements, we become aware that a wide-open dandelion flower, which has been staring at us the whole time, with its yellow florets fully expanded to the sunlight, has suddenly become animated. The next moment we see the cause. Our butterfly has been quietly sipping nectar from this yellow head of florets the whole time we have been standing there, quite concealed from our notice by its harmony of colour with that of the flower-head. Now we have startled it, and away it goes.

After gazing for a little while into a wayside pool at some flashing crimson and green sticklebacks, evidently on courtship bent, and almost forgetting how our brimstone butterfly had tricked us on the dandelion flower, we again proceed with our walk along the lane.

Just as we turn to move from the pool, though, we suddenly

see our friend of the daffodil hue returning in our direction—at all events, this is apparently the same insect. But, as it approaches, and we look more closely, we discover alongside it another butterfly, which, on account of its paler colour, was not at first so conspicuous in the distance. Our butterfly, like the sticklebacks in the pool, has evidently also been on courtship bent, and now he has found his bride, for this pale primrose-coloured butterfly is a female of his species. The two butterflies, after some frivolous caperings between the hedges that skirt the lane, disappear from view over the hedge-top.

Thus has begun the courtship of two insects which, apparently, suddenly sprang into existence on this spring morning; whence they came need not, for the moment, concern us.

Their honeymoon will last probably but for a day or so; then the female insect will give up all frivolity and devote her entire time to flying along by the hedgerows of fields and lanes, carefully scrutinizing the vegetation as she goes, and occasionally selecting out a particular shrub for closer attention. This shrub will be one of the two British species of buckthorn, either the common buckthorn (*Rhamnus catharticus*) or the alder buckthorn (*R. Frangula*). On the leaves of the buckthorn plants her tiny offspring will feed, and instinct guides her maternal sense of the requirements of the baby caterpillar which she will never see, or, at least, never recognize, even should she live to see its birth; and she often flies for miles in search of these shrubs, which in many districts are but thinly distributed.

The Egg

On the buckthorn's leaves, then, she places her tiny and beautiful eggs. Generally she deposits them either on the central midrib or on the lateral veins of the leaves, but sometimes on the intervening tissues. The eggs are about one-sixteenth of an inch in length, elongated, ribbed longitudinally,

with delicate latticing between the ribs; but it requires a magnifying lens to reveal these details of structure. In illustration Fig. 85 I have shown a magnified view of one of these pretty eggs as it is seen through my pocket lens.

Fig. 85.—The egg of the butterfly—magnified about twenty-five diameters.

The Caterpillar

We have seen the butterfly on the wing, and we have learnt where it deposits its eggs, and now we have to watch those eggs and see what they can teach us of the early stages in the development of these common but lovely insects.

The eggs when first deposited are of a nearly white colour, but after a few days they assume a yellow tone, and, later still, a deep orange shade. Some eggs deposited on May 10 assumed the orange colour seven days later; two days later still the prettily decorated shells were broken open and the caterpillars emerged from them.

The baby caterpillars, of course, are very tiny, but they waste no time, and at the end of a fortnight (June 2) with persistent and diligent attention to buckthorn leaves, they begin to become conspicuous (Fig. 86). However, these caterpillars never become very conspicuous, because they are coloured almost exactly like the leaves on which they feed. It is true that they have a white stripe running along each side of their bodies, but this only helps to make the resemblance to the leaf-stalks about which they move the greater, producing a shaded effect, just as the stalks and stems are shaded amongst the leaves.

After the caterpillars have moulted their skins several times, and are about a month old (June 20), they are full grown (Fig. 87). When resting between meals they have a curious habit of raising the head and fore-parts from the branch, this habit giving them a still greater resemblance to portions of the

FIG. 86.—Half-grown larvæ, a fortnight old—natural size.

young twigs of the buckthorn on which they feed. Fig. 88 shows one resting in this characteristic attitude.

THE PUPA OR CHRYSALIS

At this stage the caterpillar gives up feeding and prepares for the next stage in its development. It proceeds to spin

some silken threads about a stem or leaf, the silk being produced from the silk glands beneath the mouth of the larva. To this network of silk it attaches itself by means of its tail claspers. It also makes a belt or girdle of silk, which it fastens near its attached claspers. Finally, it affixes a few other silken

FIG. 87.—Full-grown larvæ feeding (a month old).

threads higher up the stem or leaf to connect and support its head and fore-parts. Then it presses out its body backwards (the strain being largely taken by the delicate silken girdle) until it assumes the form of a bow. Illustration Fig. 89 will explain the position better than any verbal description.

In this curious attitude it rests for about three days.

Meanwhile the skin of the caterpillar tightens up, and eventually breaks away at the head part, and a green pointed object appears through the opening. The skin then slowly slips downwards, being helped by wriggling movements of the developing insect, until it reaches the central or broadest part

FIG. 88.—A full-fed caterpillar resting.

of the chrysalis which is appearing to view. After the moulting skin has passed this broadest part, it then quickly shrinks into a little shrivelled ball at the tail-end against the silken threads of the stem. Illustration Fig. 90 shows the pupa or chrysalis evolved from the larva shown in the previous illustration.

Now let us recapitulate for a moment. On May 10 we had an egg, on May 18 a caterpillar, which by June 2 was half grown, or thereabouts, and on June 20 it completed its development as a caterpillar. Now, on June 22, we have a chrysalis. This bright green-coloured chrysalis remains

FIG. 89.—Getting into position to become a chrysalis.

as such generally for about sixteen or seventeen days, and then comes the butterfly. In the examples under observation all the butterflies had appeared by July 8. So we see that the complete development of the insect barely occupies two months.

In this way, from early in July throughout the month, and

perhaps into August, brimstone butterflies become more and more abundant, for then they are daily leaving their chrysalides. So at this time of the year these pretty insects become most conspicuous. Then they begin to disappear again, and, although we may see one on the wing on any sunny day

FIG. 90.—The chrysalis formed from the larva shown in the previous illustration.

throughout the months of autumn and winter, yet it is only occasionally that they are met with after August; but, as we have yet to witness the final development of the butterfly, more on this point anon.

The Butterfly

After the end of sixteen or seventeen days the insect is ready for the next stage in its development. If it is our intention to witness the actual birth of the butterfly from the

Fig. 91.—Just before the butterfly emerges.

chrysalis, we must of necessity keep a sharp look-out, for we cannot tell at what moment of day or night it will appear; indeed, it is very unlikely that we should be able to predict even the day of its appearance with any certainty.

In the illustration shown in Fig. 91 we see two chrysalides almost ready for the emergence of their butterflies. Before

this twig bearing these chrysalides I placed a camera all in readiness to record what took place. Figs. 92, 93, and 94 are the result. The four photographs—Figs. 91, 92, 93, and 94—reveal the occurrence of *one minute only*, this being just about the time occupied in the bursting of the chrysalis and the emergence of the butterfly until it shook out the folds from

FIG. 92.—Butterfly beginning to emerge.

its wings as shown in Fig. 94. It will be observed that in Fig. 92 the head of the butterfly is just appearing through the opening in the chrysalis, while in Fig. 93 the broken part is held open by the insect clinging to it by its legs. In Fig. 94 the insect has loosed its hold of this broken part, and the chrysalis, being of a horny consistency, has closed again.

It was my intention to make other photographs of the insect drying its wings, for in Fig. 94 they have not yet completed their development, and are limp and wet. The insect would in all probability have rested suspended in the manner shown for an hour or two until its wings had dried rigid and come under muscular control. However, this probable course

Fig. 93.—Out !

of events was interfered with by a circumstance which also prevented me from making further photographs, for, by a curious coincidence, just at the moment this insect had emerged from its chrysalis, the butterfly in the chrysalis seen below (Fig. 91) also made its appearance, and in doing so it came in contact with the wings of the first-emerged insect.

This untoward event caused much disturbance, and made matters very inconvenient for both insects, for at this stage they are very weak, and their strength has been severely taxed by their efforts to free themselves. Eventually, however, the first insect to emerge (which was a female) arranged herself comfortably at the tip of the branch, and this made room

FIG. 94.—The wings gradually shaking from their folds.

for the deeper-coloured male insect below. So they rested for an hour or more until their wings were ready for flight (Fig. 95).

Early in July, then, our butterflies commence their winged life in all the glory of their daffodil and primrose hues. Throughout the month and well into August they delight in

flitting about the sunny lanes, trespassing into the flower-gardens of the cottager to sip the nectar that his flowers provide, for they now no longer feed on green buckthorn leaves (Fig. 96). We should observe, too, that during this time, there is none of that winged dalliance so conspicuous

FIG. 95.—Fully-developed butterflies, hanging with wings downward so they may dry and harden.

in early spring; the daffodil male is quite content to exercise his wings by chasing another of his own colour from field to field, whereas, in the spring, his whole time is occupied in the courtship of the primrose-hued insect that is to be his bride.

So life lightly passes for them until towards the end of August, when the insects gradually disappear from view.

Where they go is a mystery that yet remains to be solved. Doubtless, in "the struggle for existence," many of them get exterminated, but that many others are in hiding somewhere is obvious from the fact that individuals come out and fly on sunny days, even in mid-winter. And then, in spring, they quite suddenly become abundant again, although, naturally

FIG. 96.—The butterfly feeding on the flowers of candytuft.

not so abundant as in early autumn, for winter undoubtedly claims its victims. Indeed, this winter hibernation may be Nature's method of weeding out the weaklings, and so saving the strongest of the race to perpetuate the species.

So, in the first sunny days of spring those individuals that have safely survived the wet, cold, and frosts of winter

attracted by the sunlight, come forth from their hiding-places. Then, in the course of their flight, they meet their mates, just as did the lonely example we observed in the lane. After which there come the wooing (Fig. 97) and the love chases, perhaps, too, a wedding tour over woods, fields, and lanes. Finally, as we have seen, about May the offspring appear.

FIG. 97.—A courting couple. The lower butterfly is the female.

The parent insects, then, having completed the twelve months' cycle of their existence, and fulfilled the functions of the winged state of their lives, give up flight, and are seen no more; or, to put it in another way, it may be said of them that, after a long and prosperous life, they died at a ripe old age.

CHAPTER VIII

The Story of the Fall of the Leaf

AFTER a night's sharp frost in autumn, we are not surprised, when we take our walk, to see the ground littered with fallen leaves from every shade of yellow to hues of the deepest red or brown; in fact, we look expectantly for this sudden spreading of a leafy carpet as a natural sequence to the change of temperature, and quite as matter of course we attribute it to the work of the nipping frost. However, before we take things so absolutely for granted, let us look a little closer into the matter and see what has really taken place; for, after all, in their own good time, surely, the leaves would have fallen, even though the frost had never been. Then, too, have we not noticed how, even from midsummer, the leaves of various plants have gradually assumed an aged appearance, the delicate green of their springtime growth giving place to darker and darker tints, until brown was reached, and that this was accompanied by a slow shrivelling of the whole leaf structure? In short, the leaves of most plants seem to reach a climax about midsummer, and then slowly decline as winter approaches, quite independently of the effects of frost.

Again, in tropical countries, where rain does not occur for several months at a time, plants act in an exactly opposite manner to those of our temperate regions, for their leaves fall before the hot, dry season; while in climates where no lengthy and alternating periods of heat and cold occur, the "fall of the leaf" is a very inconspicuous event, as new leaves form and develop at the same time that the older ones are falling

away, so that the trees appear, more or less, to be always in full leaf. Evergreens, in our own climate, present a somewhat similar case; but even these have to shed their leaves sooner or later, although in some cases they may last for several years.

It would, therefore, appear that some other potent factor or factors besides cold and frost must be at work at the time of leaf fall; and, for the nonce, our purpose shall be to trace what this influence is and how it works. Before we can make any progress towards this end, however, we must assimilate one important fact—namely, that the great engine which provides the motive power of all life, both plant and animal, *is sunlight.*

Now, the leaves of plants are organs specially constructed to intercept rays of sunlight; every leaf of every plant is adapted, so far as circumstances and environment have permitted, to present to the sunlight as much surface as possible; hence we get endless forms of leaves on different species of plants, those forms fittest for the environment naturally surviving.

In crowded situations leaves are often much divided, forming fine segments that can avail themselves of any tiny opening that presents itself in the tangled mass. In rivers, and other open places, where there is no need for such a division of the leaves, they are generally more integrate, and perhaps rounded in form. However, to properly understand how perfectly and systematically arranged are the leaves to intercept sunlight, a large tree, such as a horse-chestnut, maple, or elm, should be viewed during sunlight from a height slightly above it, when every leaf in view appears to be placed in that position, and at that angle, which allows it to present the boldest front to the source of light, while receiving the minimum amount of shadow from its near neighbours.

This mosaic arrangement of the leaves is a most important factor in the economy of the plant. Only in sunlight is it possible for the leaves to carry on their function of manufacturing the food materials required in the building of the plant structure. Therefore the object of every individual is to

receive the maximum amount of sunlight. With the energy derived from this captured sunlight, the leaves are enabled to absorb carbonic acid gas from the atmosphere—which gas we and all living organisms are constantly exhaling in the process of respiration; and, in addition, the chimneys of our houses and manufacturing works are daily passing into the atmosphere many thousand tons. By means of the very numerous and extremely minute granules of green colouring matter contained in the tissue of the leaves, this carbonic acid gas is then chemically united with the water continually supplied from the soil through the roots. The products of this combination are, first, the necessary sugars, and, later, more complex materials from which the plant derives its growing energy.

In the process of manufacturing these food materials, oxygen gas is given off as a waste product—waste so far as the plant is concerned. It will be seen, therefore, that while animals pollute the atmosphere by exhaling carbonic acid gas, plants, in the process of feeding, absorb and decompose this poisonous gas, retaining the carbon which it contains for their own use, and giving back its pure oxygen (which is of no use to the plant) to the atmosphere. Thus the animal supplies the carbon which is the chief food of the plant, and the plant in return affords the pure oxygen so needful to animal life.

As previously remarked, a continuous water supply is necessary in the feeding process of the plant, and this is, of course, absorbed from the soil by the roots. From the roots it is passed through wood and pipe-like tissues up the stem to the leaves, and there the water-mains, so to speak, thin down and form a delicate network (popularly known as the veins or nervures), eventually becoming lost amongst the more simple cellular structure of the leaf. Here, then, we have the plant feeding on carbonic acid gas by means of its leaves, and drawing water from the soil through its roots.

Although a leaf is generally but a very flat, thin structure, yet it is built up of several kinds of tissues. If we examine a

section of a leaf under a microscope (Fig. 98), we find that above and below there is a surface skin or epidermal layer, and that between these layers two other kinds of tissues appear, amongst which the vascular strands or veins are embedded. The two epidermal layers in most leaves show a very different appearance; the upper layer is formed of rounded or, perhaps, brick-shaped cells placed closely together, and forming a strong protective covering to the more important tissues beneath.

Fig. 98.—Section of leaflet of the horse-chestnut, showing internal structure.

The lower layer is generally formed of similar cells, but between them are innumerable tiny pores or stomata, through which the plant transpires superfluous water, in the form of aqueous vapour—or we may compare these pores with the perspiring ducts in the skin of an animal.

These stomata or openings of the lower epidermis lead into air cavities amongst loose, chain-like tissue, which occupies the lower half of the leaf, and above these spongy cells one or more layers of elongated or palisade cells are placed like

bricks on end, with little or no air spaces between them. The topmost layer of these palisade cells comes in contact with the upper epidermal layer previously referred to. Both the spongy and palisade cells, and especially the latter, are crowded with the very minute but most important chlorophyll bodies, or green-coloured granules, which produce the green colour of the leaf and play the important part of absorbing the light and heat energy of the sun's rays. By means of this absorbed energy the chlorophyll bodies in the laboratory of the leaf manufacture the living materials which build up the plant structure.

It is in the palisade cells that the sugar is manufactured, and to carry on their work these cells need a constant supply of water. The water comes up laden with soluble inorganic materials—such as soda, potash, lime, etc. These substances have been gathered from the soil by the delicate root-hairs, which secrete an acid fluid to make them soluble. Thus we find provided what we call vegetable sap.

It is a very controversial point, but one of great interest, how this watery current is kept rising from the roots, often several yards beneath the earth, to the topmost twig of the highest tree. Probably the most plausible theory is the simplest and easiest to understand. It is well known that many mineral salts have the property of becoming deliquescent. Let us, for example, expose a little chloride of lime to the atmosphere. In a short time we observe that, although no water has been placed near it, yet it has become deliquescent from the moisture which it has absorbed from the atmosphere. Here, then, we have suggested the probable explanation of how the sap rises.

The sap has, as we have seen, carried up in solution various mineral salts, and the leaves during sunlight are continually transpiring a watery vapour through the stomata or openings on their under sides. The salts cannot evaporate from the leaves with the water, and are therefore left behind in the cells, and these salts, like the chloride of lime, have a very great affinity for water. Now let us commence with the

conception of a continuous stream of sap from the absorbent cells of the root-tips to the evaporating surface on the under side of the leaves in the atmosphere above, and let us realize that the cells of the leaves are continually drying (through the evaporation of their moisture), and that their contained salts are just as continually seeking more water. Now, a dry cell naturally absorbs the moisture from the one beneath it; just as a dry sheet of blotting-paper would suck up moisture from a damp sheet placed beneath it. Carrying this principle from the leaf down throughout the whole length of the plant to the root-tips we have an upward current set up and maintained, and the larger the evaporating surface (or number of leaves) the greater is the pull. So it is probably that by this simple, but nevertheless wonderful, method a continual current of water and soluble mineral substances is supplied to the plant.

This rising sap reaches the leaves by means of the water pipes (or veins), and then diffuses through the palisade and other cells. To the palisade cells, also, the carbonic acid gas finds its way from the atmosphere, entering through the stomata or pores of the leaf, into the air chambers of the spongy tissue in which these pores open, and from these air spaces it diffuses to the palisade cells. There, under the influence of sunlight, the tiny chlorophyll bodies, or green granules, decompose this inorganic carbonic acid gas, and the carbon derived from it they combine with the water and soluble mineral matters to form those organic substances *on which all life depends*—substances that are full of energy or life movement; energy that will not only sustain plant life, but animal life also. Animals, indeed, are entirely dependent on these energy-yielding products of the plant for their very existence.

How very important these tiny chlorophyll bodies of the leaves become when we see in them the food manufacturers for everything that lives! Although we, or other animals, may eat animal food, yet the animal on which we feed must have directly or indirectly obtained its sustenance from the vegetable world. For, as we have seen, plants alone possess the power to convert inorganic or non-living material into organic or

living. The animal to build up its structure must use pre-organized material; for it does not, like the plant, possess in its tissues the marvellous chlorophyll, with its ability to utilize the light and heat from the sun's rays, and by the motive power so obtained manufacture energy-yielding sugars and starches from the inert elements of carbonic acid gas and watery sap. To put the matter clearly and simply, the plant builds, but the animal destroys.

It is true that, low down in the scale of life, where animals and plants approach each other very closely, some insignificant animals possess chlorophyll in their tissues, and probably along with it feeding powers similar to those of plants, but as these animals also feed on organic materials, and have characteristics common to both plant and animal organisms, we need not consider them as exceptions to the general rule, but rather as intermediate organisms.

From what has been said it is obvious how very necessary and important is a continual water supply to growing plants. When the water current slows down, so, as a natural consequence, do the living processes within the plant. When the current ceases to flow, the plant slowly shrivels and dies.

Having followed the working functions of a green leaf to this stage, we are now in a position to understand why leaves sometimes fall before hot, and sometimes before cold, periods.

We have seen that leaves are continually transpiring watery vapour from the stomata, or openings on their under side; this transpiration is, of course, kept more or less active according to the dryness of the surrounding atmosphere. In very hot weather it is apparent that transpiration would be most active, and this at a time when most inconvenient to the best interests of the plant, for then the soil would be so dry that it could not supply the increased demand made upon it. Hence it obviously follows that if a plant growing in a hot climate could dispose of its leafy raiment (which represents its transpiring surface) before the dry season, and so largely shut in the

store of moisture that it then possessed, it would be adopting a most protective measure. Such is the way, then, by which, when the water supply begins to flag, such plants prepare to meet the situation, and, in due course, when the dry season arrives, their leaves fall, and the so-called "summer sleep" commences.

Later in the season, when moisture again impregnates the soil, and the water supply within the plant is naturally very low, the mineral salts in the plant tissues greedily absorb any moisture that comes their way, and so the young roots are incited to seek for greater supplies. There is also another factor, known amongst botanists as "root-pressure," which plays an active part in starting the upward current before the transpiring leaf surface gets to work, but the function of this is not very clearly understood. By "root-pressure" water is passed into the cells of the roots and cannot again get back to the soil. Eventually the absorbing salts within the plant detect its presence, and then the upward current commences, and, given a moderately warm temperature, growth and development at once begin to take place.

If the "fall of the leaf" before hot, dry periods can be so explained, what of our own climate, where the exact opposite, a long, cold, and damp period, occurs? We know quite well that the leaves fall before the winter sets in; but that their fall cannot be associated with a lack of moisture is obvious. What, then, is the influence at work in this case?

Let us suppose that we have a delicate, sensitive plant growing as a pot plant, and that we water the soil in which it grows for a few times with very cold water. Although the surrounding atmosphere may be most favourable to its development, and the temperature of the soil well above zero, yet we find that the leaves of our plant begin to flag, and soon the whole plant looks as if it had been nipped by frost. What has happened? The very cold water has lowered the temperature of the soil so much that the activity of the roots has been interfered with, and, as a natural consequence, their absorbing powers have decreased. But the leaves in the

warmer atmosphere above have gone on transpiring aqueous vapour as usual; hence the tissues have lost their water and it has not been replaced. So the plant at first becomes flaccid, and then later shrivels up and dies.

In the climate of Britain, as the soil cools with the decreasing power of the sun's heat, the functions of the roots are retarded in a similar manner to those of the sensitive plant just referred to, and the trees respond early to this decrease in the water and mineral supplies. By the time that the supplies would become quite inadequate the trees are ready to meet the situation by shedding their leaves. In this way their evaporation surface is reduced to a minimum, while the necessary water supply is largely reserved beneath the protective bark of the tree to serve through the period when the supplies will fail more or less completely.

At the same time, also, by thus disposing of their leaves, trees avoid other serious dangers. Water in the tender tissues of the leaves during times of frost would be most dangerous to the plant structure, for then it would become ice, and with the expansion that takes place when water freezes the tissues would be ruptured. How dangerous such an enemy would be to the delicate vegetable cells can be readily demonstrated by the bursting of a water-pipe, when the water contained in it expands in the process of freezing. (It is a popular error to suppose that the thaw bursts the pipe, an error which arises from the fact that usually the damage is first detected when the thaw sets in and melts the ice in the pipe. It is evident, though, that when the pipe burst it was filled with ice.) Another danger, overcome by the absence of leaves, is that of heavy falls of snow. Trees covered with foliage during heavy snowstorms get their branches sadly broken by the weight of the snow and by the pressure of the wind against its mass.

It should be observed, too, that trees in the lowlands retain their leaves several weeks longer than those of elevated mountain regions, even when of the same species. In the latter situations snow and frost often occur in the autumn months,

and consequently the soil is cooled sooner than that of the lowlands. From this we might suppose that these mountain plants would have to put forth their leaves several weeks earlier in the year than their lowland relatives. As a matter

Fig. 99.—At the first indication, in late summer, of a lowering temperature, some peculiar layers of cells begin to form at the base of the leaf-stalks, and quickly extend across the tissues and disconnect them.

of fact, the exact opposite is the case, for the mild temperature of spring is later in reaching these elevated regions; hence it comes about that in these colder quarters those trees survive best which have adapted their season's work to commence a

few weeks later, and finish a few weeks earlier, than the normal period.

We may reasonably assume, from what has been said, that the "fall of leaf" is chiefly a protective measure adopted by

FIG. 100.—Horse-chestnut branches showing the connection and separation of the leaf-stalk and stem.

the plant against transpiration at times when it would be injurious to its economy, and that it is brought about by either heat or cold.

The widespread idea that the sudden frost is the cause of

FIG. 101.—A longitudinal section of the branch shown to the right of Fig. 100, at the part marked $\ddagger$. The tissues of the leaf-stalk, it will be observed, are being gradually separated from the stem by the layers of developing cork cells. Eventually the cork cells extend completely across and sever the leaf from the stem.

the "autumn fall" is, at least, a too hasty conclusion. For weeks before the frost, which has apparently done so much mischief, occurred, the tree has been preparing to meet this emergency. At the first indication, in late summer, of a lowering tempera-

Fig. 102.—A similar example to Fig. 101, but further developed, showing the cork layers when they have extended completely across the base of the leaf-stalk, when the leaf is ready to fall.

ture, some peculiar layers of cells begin to form at the base of the leaf-stalks, and quickly extend across the tissues, disconnecting them. A magnified section of a leaf connection from a sycamore tree is shown in Fig. 99, which reveals an early stage in the development of these separating cells.

These layers of newly formed cork cells separate very readily, so that when mature the slightest puff of wind is sufficient to detach the leaves. If, however, we look at the scar left on the branch (of a horse-chestnut tree, for example)

FIG. 103.—Connection and separation of the leaf-stalk and stem of sycamore tree.

where the fallen leaf was attached (Fig. 100), we see where the tubular tissues or veins which passed into the leaf have been cut off, but there is no open wound left; all is carefully sealed over with a cork or bark sheet. Illustration Fig. 101 shows the internal aspect of the stem on the right of Fig. 100

FIG. 104.—A longitudinal section of the part of the stem marked ‡ in Fig. 103. Here the leaf-stalk is seen to be nearly disconnected. Above in the axil of the leaf-stalk is seen the bud for the next season's growth.

at the part marked $\frac{+}{+}$, and some further details are shown in Fig. 102. Illustrations Figs. 103 and 104 show analogous examples in the case of the sycamore tree.

On the other hand, if, in early summer, we remove a leaf, it leaves an open wound of broken tissue. Also a branch cut from the tree at this period does not lose its leaves even when thoroughly dry and dead, because the tissues of the leaf and stem are still connected.

It is plain, therefore, that the tree has most carefully and systematically prepared for this autumn fall. The sudden nipping frost arrives, perhaps, just when the corky or bark cells have almost completed the separation. The moisture finds its way into the disintegrated tissues and freezes there, and, as previously explained, expands in the process of freezing, with the result that the tissues are then completely disconnected; but the leaf does not fall immediately, for the ice holds it in contact. Then, the following day, the warm sunshine dissolves the ice, and so thousands of leaves fall simultaneously, helped, or rather hurried, in their fall by the frost, it is true; but the frost has not by any means been the cause of their downfall.

Indeed, so thoroughly has the plant prepared to denude itself of its leaves, that long before the separation takes place everything useful in its economy has been carefully removed from them and withdrawn into the trunk and branches, to be safely stored beneath the protective bark. So the rich, energy-yielding starches are reserved in readiness to render service in the growth and development of the following spring. Then the leaves lose their green-colouring matter, and the exquisite autumn tints appear, varying in hue according as the disorganizing acids do their work in the leaf. Eventually the dead framework of cells falls, and carries with it the waste salts and other materials that have become burdensome to the plant. This feature probably explains the fall in those countries where there are no extremes of heat and cold, and where trees are more or less always green.

It only remains to add that this action of plants in stripping themselves of their foliage must not be looked upon as

an instinctive foresight on the part of the plant, or a conscious anticipation of the dangerous time coming, but rather as the outcome of adaptation to environment, those plants surviving best, in countries of extremes of temperature, which have most developed the characteristic of a period of work alternating with a period of rest.

CHAPTER IX

The Life Story of the Swallow-tail Moth (*Uropteryx sambucata*)

TWILIGHT had disappeared, and it was almost dark on a close and sultry night in the first week of July. The air was calm and still—an ideal night for moths, for these creatures love warm, dark, windless nights in which to conduct their silent flittings along the hedgerows, garden paths, and woodland glades; and under such favourable circumstances the business of life runs apace with them. They sip nectar from every night-blooming flower whose sweet fragrance and pale-coloured petals attract them; they seek their mates and carry on their courtships with a due sense of their responsibilities; and select suitable sites on which to deposit their tiny and beautiful eggs, almost without a pause, until daylight bids them get into hiding again. Even then, in the early morning hours, belated individuals may always be found drowsily resting on fences and tree-trunks, too tired to get under cover; but an hour or so later they mysteriously disappear somewhere, and are not seen again until nightfall.

On this ideal moth night these nocturnal insects were abundantly in evidence in my garden. All sorts and sizes were abroad, although some of the darker-coloured and smaller species required the practised eye to detect them in the night light. And as they whirled about, suddenly, hovering over the dark foliage of some black-currant bushes, a large white or pale-coloured moth appeared. For a moment it fluttered

above the bushes, and then, like a great snow-flake, dropped down on to one of the dark green leaves.

Yes, it was the first swallow-tail moth of the season, and judging by its large size it was a female insect. I waited, for I knew by its actions that it was engaged upon the all-important duty of egg-depositing. After a time it devoted its attentions to another leaf, working beneath it in a very careful manner, and later still another leaf, which was well within my reach.

FIG. 105.—The tiny eggs are laid on the underside of the leaves in groups of six to twelve. Three groups are shown of natural size.

A few minutes afterwards the moth was beneath a large bell-glass, with a good branch of currant tree in water. The branch from which I captured it I duly marked and left until daylight.

THE EGG

Next morning I carefully examined the leaves around which the moth had been moving overnight; and scattered about beneath them were, here and there, little white or pale

yellow patches, each of which represented from six to a dozen of the insect's eggs. Some of these are shown in illustration Fig. 105 of natural size, while Fig. 106 illustrates one of these groups as seen through the microscope, revealing the beautiful forms of these tiny objects, the truncated ends and raised ribs in the direction of their length, these latter being united by delicate transverse bars.

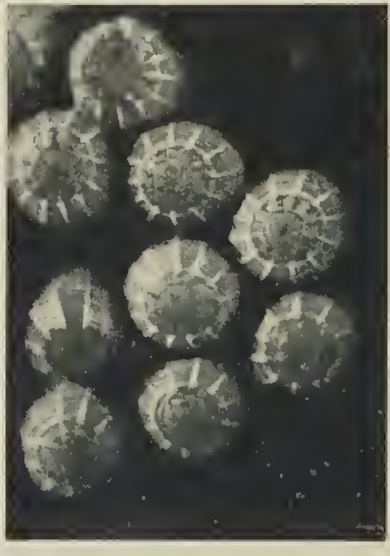

Fig. 106.—One of the egg groups as seen through the microscope.

On the marked currant leaves I found between fifty and sixty of these eggs, and in the course of the night the moth deposited a little over four hundred others. So that, presuming these represented the whole batch, and that none had been laid elsewhere before the moth was captured, we have nearly five hundred eggs from a single moth. In view of this, I need scarcely remark that the swallow-tail moth is a very common and abundant insect. However, there is a reason for this prolific egg-depositing, as we shall see later.

The Caterpillar

When the eggs are first laid they are of a pale yellow colour, but two days afterwards acquire a deep orange shade, and this colour change is the first sign that the eggs are fertile. Exactly fourteen days after the eggs were deposited, the tiny larvæ or caterpillars emerged. They are about three-sixteenths of an inch in length, of a dark brown colour, and have hair-like bodies with large heads, which they wave about in a very lively and comical manner, while holding on to the plant by their tail claspers. Each caterpillar, as soon as it is hatched,

moors itself to a leaf by a silken thread of its own spinning, as a precaution against getting blown or shaken off; and in case such an accident occurs, it climbs back to the food

FIG. 107.—The young caterpillars hold to the veins of the leaves in their characteristic stick-like attitude, even when but a week old.

leaf again by means of this thread, consuming its line as it ascends.

At first the young larvæ are almost too small to be apparent,

but at the end of a week they begin to become more conspicuous, and make their presence felt on the food plant. They may then be readily seen standing about the veins of the leaves in their characteristic stick-like attitudes (Fig. 107). This resemblance to twigs, however, becomes much more evident as they grow older. Illustration Fig. 108 shows some eight larvæ about a month old in their favourite resting attitudes on a twig.

Fig. 108.—Eight larvæ resting in their favourite attitudes when a month old.

One near the centre is seen to be suspended from the branch by its silken thread. In illustration Fig. 109 they are represented at four months old, six caterpillars being here shown, although these may not be distinguishable as caterpillars at first.

Two of the three larvæ shown in the centre of Fig. 109, it will be observed, are using the third as a support on which to

stand, and this one is holding to the branch only by its tail claspers, although bearing the weight of the three, showing the enormous strength of these larvæ—for really, when one thinks of it, it is an extraordinary feat of strength for a soft-bodied

FIG. 109.—Swallow-tail caterpillars four months old. Observe the centre three, two of which are supported by the third, which is holding on by its tail claspers only.

caterpillar. Our wonder grows when we consider that they often remain immovable in these attitudes, if not interfered with, throughout the day, perfectly simulating the twigs of the branches which surround them, and in this way evading the sharp eyes of birds and other enemies likely to prey upon

them. If we see them at night, however, a very different picture is presented: then they are all looping about from leaf to leaf in a most businesslike fashion—for it is feeding-time, and their enemies are few.

The illustration Fig. 109 was photographed at the end of

FIG. 110.—A full-fed caterpillar at rest on a branch.

autumn, and shows part of the last branch of food material obtainable for the larvæ. But as the caterpillars are only about half grown at this time, and no more green leaves can be obtained for them, their further progress would seem to present a difficult problem. However, Nature has taught these insect

twigs how to tide over winter just as well as she has the true tree twigs.

As the leaves assume autumnal tints, the voracious appetites of the caterpillars begin to decline; and as the leaves fall, the larvæ mysteriously disappear from view, selecting suitable situations amidst the bark of trees, in the forks of branches, and similar places where they can best withstand the cold and

FIG. 111.—A group of six full-fed larvæ resting.

frosts of winter, and here they become immovable "twigs" for the winter months.

I have previously observed how abundant were the eggs or ova of this insect, and most of the larvæ produced from them reach the autumn successfully. It is comparatively few, though, that survive the drenching rains and freezings and thawings of the winter months. It is then that Nature weeds out the weaklings and selects those individuals which are best able to

carry on the species. Whenever the green leaves begin to appear, by some strange instinctive prescience the caterpillars awake from their torpor and steer directly for them. It is true that, after this long fast, they look thin and wan compared with their autumn appearance; but once they commence to feed again, their rate of progression is astonishing.

In the spring, about a month from the time when they start to feed, they are full grown, and their marvellous resemblance in colour, form, and the positions they assume, to twigs of the tree, has to be witnessed to be properly appreciated. Individually these larvæ differ in colour just as living twigs or branches do: some are grey, others of a green shade, others brown, and every combination of these colours may be found; while each again assumes a different angle with the branch on which it rests; the head and anterior legs become like an undeveloped bud, and near the centre of the body is a small hump which gives the appearance of a node on the twig. In brief, this mimicry of the twigs of the food plant is so perfect that many times, when I have pointed out these larvæ to friends, I have been quite unable to convince them that they were living caterpillars without first touching them and so causing movement (Figs. 110 and 111).

The Pupa or Chrysalis

About the middle of May the caterpillar ceases feeding, and selects a clear space on one of the branches, to which it holds firmly by means of its tail claspers. It then stretches itself out to the adjoining leaves, biting out small pieces of these with its mandibles, and threading them together by means of silken strands which it spins for this purpose, eventually forming a leafy hammock. In illustration Fig. 112 two larvæ are seen engaged in making their cocoons. The example on the left side, it will be observed, is resting amidst its partly-made cocoon, its body passing right through it. This photograph was made at 11.30 in the morning, while the next, Fig. 113, shows the caterpillars working at their cocoons at 5 o'clock in

the afternoon of the same day. At 11.30 a.m. next day the cocoons were sufficiently advanced to permit the caterpillars to loose their hold of the branch and to drop down into them (Fig. 114), although there was much work yet to be attended to inside, as the example to the left shows, where the larva is seen to be busy at work when the photograph

FIG. 112.—Two caterpillars engaged in threading bits of leaves about their bodies to form a cocoon.

was made. The cocoon to the right was much nearer completion.

After much twisting and writhing within the cocoons, placing a thread here and another there, everything is at last made comfortable. The larva then uprights itself—for, as the illustrations show, the caterpillars make their cocoons in a head-downwards position—and waits for Nature to do her part. Six

days later a wriggling motion takes possession of the caterpillar within its cocoon, and by carefully peeping between the interstices of the loosely attached leaf fragments which form the cocoon we may see the larva moulting its last skin, which is pushed to the lower part of its leafy hammock, and then, instead of a caterpillar, there appears a fleshy or purple-coloured pupa or chrysalis,

FIG. 113.—Caterpillars working out their cocoons.

which about two hours afterwards becomes dark-coloured, similar to the original larva.

The illustration shown in Fig. 115 was photographed eight days after that shown in Fig. 114. Here it will be seen that many of the leaves have shrivelled, and that the cocoons contain chrysalides instead of caterpillars.

At this stage an unlooked-for catastrophe occurred. Another larva that desired to form its cocoon incidentally happened

while seeking a suitable site, to meet with the two completed cocoons. And then an unscrupulous idea apparently took possession of it—for there are even unscrupulous caterpillars. This idea was—how much easier it would be to steal the material from these two cocoons to make its own than to gather it for itself. Soon the chrysalis in the cocoon shown to

FIG. 114.—Next morning the cocoons were sufficiently advanced to allow of the caterpillars loosing their hold of the branch and dropping down into them.

the left of the illustrations got pushed out, and dropped down towards a lower branch, and would have fallen to the ground except for a strong silken thread which was attached to its tail-end. The cocoon was then coolly appropriated by the unscrupulous caterpillar, and re-stitched up. Illustration Fig. 116 shows the two cocoons; below the one appropriated is suspended the ejected chrysalis.

The Perfect Moth

Exactly one month from the time the two larvæ commenced to form their cocoons (May 20) the moths appeared (June 20). Of course, there was no means of ascertaining just when an emergence would take place, as it might occur at any moment, night or day, from the end of the third to the end of

Fig. 115.—The cocoons contain chrysalides instead of caterpillars.

the fifth week of the life of the pupa. The cocoon to the right, which I have previously remarked was most advanced, matured first, but it unfortunately happened that I was too late to see the moth emerge, but found it resting on the branch above its empty cocoon. The emergence had evidently taken place during the afternoon, for it was now evening, and the moth was fully developed. To make the best of a bad job, I set about

photographing the moth at rest. As it was getting late, this necessitated a long exposure; and while the cap was off the lens, the suspended chrysalis suddenly began to wriggle and vibrate, and almost immediately the pupa split near the top—

FIG. 116.—The chrysalis ejected by the unscrupulous caterpillar is seen hanging below.

it will be remembered that it was hanging upside down (Fig. 116). The head and antennæ, or feelers, of the moth quickly peeped through, followed at once by the legs and thorax; then more slowly the cramped and folded wings were withdrawn, and then it paused, the body still remaining

within the pupa-case. A minute afterwards the moth bent its body forward and stretched out its fore legs, gripped the pupa-case, and then dragged out its body, and so was left clinging to its late domicile.

Had it been earlier in the day when the light was good, and

FIG. 117.—The newly emerged moth resting on its empty chrysalis.

a rapid exposure possible, nothing more desirable could have occurred, but as it was after eight o'clock in the evening, the vibration, in this uncertain light, spoiled my picture; and I had to set a plate for another. The exposure was made without a moment's loss of time, and the result is shown in Fig. 117.

The newly emerged moth is seen clinging to its empty pupa-case, its wings not yet fully lengthened out, while above it is the moth which was to be photographed at the time of this second moth's emergence.

Almost as soon as the exposure had been made the moth

Fig. 118.—To the right is the moth that first emerged from chrysalis; the second to emerge is seen on the left, climbing its cocoon.

moved again, higher up the cocoons, and then the camera was switched round and the two moths were photographed together (Fig. 118). Here it will be seen that the wings and the body of the last-emerged moth have further lengthened out, and almost completed their development.

Such, then, is the life story of the swallow-tail moth, from its fourteen days in its tiny and beautifully sculptured egg, through its ten months as an alternately hungry and dormant stick-like caterpillar, its four weeks in a leafy and silken hammock as a pupa or chrysalis, until we see its lovely pale

FIG. 119.—An occasional sip of nectar is all the nourishment they need in their winged state.

primrose wings. These, when fully spread out, often extend two and a half inches across, and the hindmost pair are cut into acute tails, from which the insect derives its popular name —"Swallow-tail."

Life of the Perfect Moth

To reach its winged state we have seen that it takes the moth eleven months and two weeks, which leaves two weeks to complete the cycle of the year. Judging from a large number of these moths that I have kept in captivity from their emergence from pupa, two weeks is about the average length of their winged life, so that their development requires twelve months almost exactly.

They will breed readily in captivity. The two moths shown in the illustration (Fig. 118), both of which are females, deposited between them over a thousand eggs within a week after emergence from the chrysalis, and both died a few days later. They were kept under a large, well-ventilated bell-glass, with plenty of green foliage and flowers of elder. One of the male insects is shown in Fig. 119 with its long tongue unrolled, sipping nectar from the elder flower, which they seemed to enjoy in captivity. An occasional sip of nectar is all the nourishment they need in the winged state, their caterpillar stage being the chief feeding time.

In conclusion, I should mention that, although I have spoken of the black-currant tree as the food-plant of the larvæ of this insect, yet this is by no means the only plant on which they feed; in fact, I had never previously heard of them feeding on this plant, but simply followed the hint given by the mother insect as to the best food for her offspring. The usual food-plants are elder, honeysuckle, lime, pear, and other fruit trees, and some herbaceous plants, amongst which the common forget-me-not is a favourite.

CHAPTER X

The Story of a Piece of Coal

AFTER considering the wonders and romance in the lives of butterflies and moths of lovely hues, a piece of coal may seem a very uninviting and unromantic subject. And, so long as we approach it with gloved hands and a length of tongs, coal is likely to remain unromantic. However, a closer investigation of this valuable mineral (which at one time in its history belonged to the vegetable kingdom), gives us glimpses of one of the most interesting periods in the history of our planet.

We should have to go back to a very remote era to see our coal as flourishing vegetation: to a period which the geologist terms the "Carboniferous Age." At this epoch of the earth's history man had not yet appeared, nor for many millions of years to come was his race destined to dawn. In fact, there were no fewer than nine subsequent geological periods to follow before his advent, each of these stupendous cosmical changes representing the work of millions of years; for a million years is but a small period of time geologically considered.

Not only had man still to present himself, but most other land vertebrates had likewise to appear. There is reason to believe that the first of these latter appeared during the Carboniferous period, and represented the extinct amphibians known as labyrinthodonts—a kind of large frog, probably about the size of a small ox. Other large animals existed in the way of scaly alligator-like reptiles, which, together with the several

species of labyrinthodonts, represented the principal and largest animals of the period. The smaller animal-fry were made up of tree-lizards, land snails, large scorpions and spiders, cockroaches, beetles, huge mayflies, and other marsh insects. The seas were at the same time alive with coral banks and shell-fish of wondrous kinds, including the first known oysters which have survived through all the subsequent periods. Various species of ganoid fish, allied to the sturgeon, armoured with brilliant enamelled plates instead of the horny scales of the fishes of later periods, were also abundant in the waters—all these animals having left traces of their existence in the fossils of the Carboniferous strata.

In a like manner we find, recorded by the rocks and slabs of the coal measures, a history of the plants which existed during the period. On examining these we find that, as with the animals, the higher forms are absent. The fossil plants of the coal shales reveal none of the higher flowering plants, but the more lowly forms, such as horsetails, club-mosses, ferns, and similar species belonging to the lower orders.

And when we consider the class of animals that existed during the Carboniferous period together with the plant life, we can arrive at a tolerably satisfactory conclusion regarding the climate and natural surroundings which prevailed amongst them. All point to a semi-aquatic or semi-terrestrial order of things; probably a humid and balmy atmosphere, without extremes of heat or cold, existing over large areas of flat, marshy, luxuriant forests.

Now, every one who has gathered or observed our humble club-mosses and horsetails, will naturally wonder how luxuriant forests could be formed by such insignificant plants as these. And even ferns, and an occasional tree-fern, would scarcely make a forest that could be termed luxuriant. However, I will ask my reader to glance at the fossil root-end of the horsetail plant taken from the coal measures and shown in Fig. 120 and which the geologist terms a *Calamite*. The illustration represents it at about one-fifth of its actual size. Some idea of the diameter that horsetail stems assumed in the Carboniferous

period will be gained when I add that this is a comparatively small specimen. But, even so, compare it with the representative of the horsetail family of to-day, shown in Fig. 121 at natural size, and it will be at once realized that our modern species are but diminutive and puny descendants of a class of plants that once produced enormous tree-like structures. Some of the various species of calamites, or ancient horsetails, in fact, attained the dimensions of trees, being sometimes sixty or

FIG. 120.—Fossil *Calamite* or horsetail stems from the coal measures. The example to the right shows the root end—one-fifth natural size.

seventy feet high, with stems often over a foot in diameter. The horsetails in the Carboniferous period were some of the most conspicuous and leading members of the vegetable kingdom.

Perhaps even more abundant were the club-mosses of which, to-day, we have but some half a dozen species indigenous to the British Isles; in the Carboniferous times there were forty or more. But these, instead of being little moss-like hillside plants, like our present forms—a branch of a cultivated form

Fig. 121.—A modern horsetail plant and club-moss—natural size.

is shown at the lower portion of Fig. 121—with stems perhaps one-sixteenth or one-eighth of an inch across, grew, like the

FIG. 122.—Coal shales bearing impressions of fronds and frondlets of the ferns of the Carboniferous period—one-half natural size.

horsetails, into tall trees, with trunks often four or five feet in diameter. Fossil specimens, a hundred feet long, have been found, and it is probable that they reached much greater sizes.

These great club-mosses grew abundantly and scattered their myriads of seed-spores and spore-cases; season after season these spores and sporangia rained down in accumulating masses around their roots until deep and dense layers were formed; and so to-day we frequently get coal that is more or less completely built up of these resinous spores. Our bituminous coal owes its bright and glossy appearance and brilliant flame when burning to the presence of this altered resinous matter. The two examples to the left of the bottom row in Fig. 122 show portions of coal in which the seed-spores are quite visible.

The geologist terms these gigantic club-mosses *Lepidodendra.* The stem or trunk of a *Lepidodendron* is covered with scars where the leaf-stalks were originally attached; and these trunks are often found standing upright in the coal-mines with their conspicuous scars arranged spirally around their whole length. The sandstones and shales found above the coal strata often reveal fossilized portions, and casts or impressions of the scaly bark of these great stems, some of which are shown in Fig. 123; the labelled specimen shows a large scar which is thought to represent the spot where the fruiting or seed cone was attached.

Other curious fossil branches are commonly found in the underclay below the coal-beds, and these for a long time puzzled geologists; however, they named them *Stigmaria.* These eventually were recognized as roots of *Lepidodendra* and *Sigillariæ.* In Fig. 124 portions of these fossilized roots are shown, the circular scars marking the points where the rootlets were originally put forth. Some of these main root branches have been found extending for ten or twelve yards, with diameters in their thickest parts of from two to three feet.

Another class of great plants of the Carboniferous forests were the *Sigillariæ*, whose stems, like those of the *Lepidodendra*, are characterized by their regular leaf-scars. Fig. 125 shows two coal shale casts of portions of the scaly and fluted bark of these plants. A trunk of a *Sigillaria* found in Germany *in situ* measured at its base no less than six feet in diameter.

FIG. 123.—Sandstone casts of the scaly stems of *Lepidodendra* and similar plants from the coal measures. To the right is shown a portion of the fossilized root called *Stigmaria*—one-third natural size.

If we add to the plants already mentioned certain coniferous trees similar to our pines and larches, we shall understand that the forests of the coal period, although largely composed of what we now regard as insignificant weeds, were not by any means insignificant as forests. In short, everything

FIG. 124.—Portions of the fossilized roots of *Lepidodendra* called *Stigmaria*—one-quarter natural size.

points to the fact that the forests were so dense as to be almost impenetrable through the various plant growths, individuals of which would be striving one with another to get their leaves or fronds exposed to the sunlight, in the same manner as the living plants in crowded situations do to-day; for the sunlight was just as important to these early plants as it has

always been to all plant life. On this point, however, I shall have more to say anon.

In amongst the great stems or trunks of the horsetails, club-mosses, and other allied plants, there would be a dense

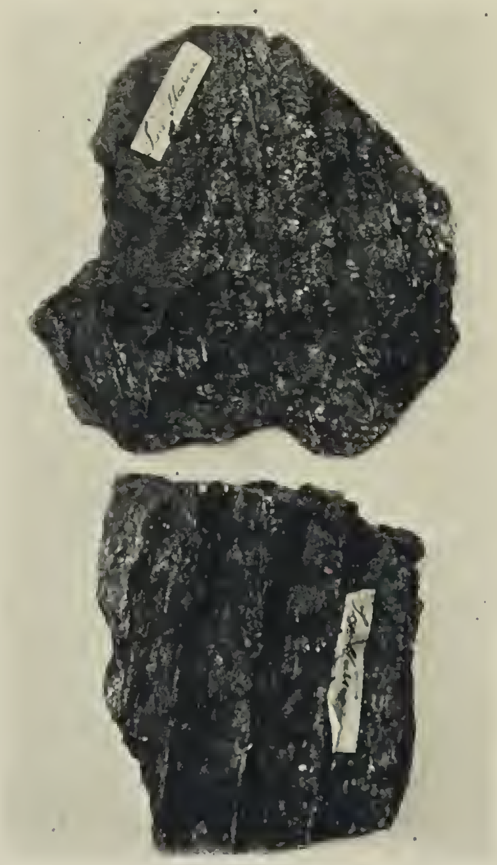

FIG. 125.—Coal shale casts of the scaly and fluted stems of *Sigillar a*—one-quarter natural size.

undergrowth of ferns, many of which were similar to their living representatives of to-day. The remains of these are abundant in nearly all coal shales and sandstones—so abundant, indeed, that twice as many species have been found preserved thus in our English coal measures as can be found living at

the present time in the whole of Europe. Not to mention large tree-ferns similar to modern tropical examples which undoubtedly had a habitat in England during the coal age. Fig. 122 shows portions of shales bearing impressions of various fronds and frondlets of the ferns of the period. The two central examples in the top row will be seen to represent cameo and intaglio pieces, and when closed together these became simply a piece of smooth weather-worn stone with its secret hidden within its core. Thus do the rocks reveal the story of what has occurred on the earth ages before man and his contemporaneous living forms appeared.

We have now to trace the connection between these luxuriant forests of the Carboniferous age and our present beds or seams of coal buried sometimes more than a thousand feet down in the bowels of the earth.

In the first place, let us examine coal itself and see if it, like the slates and shales, reveals to us any of its history. It would be useless to look at any casual piece of coal we might take from the scuttle in order to trace its vegetable origin; but by cutting a thin piece and grinding it carefully between glass with emery and water until it becomes so thin as to be transparent, and then submitting this to microscopical examination, we should probably discover something as to its structure.

In Fig. 126 is shown such a thin and transparent section of Yorkshire coal magnified about twenty diameters; while in Fig. 127 is a section, also magnified, of the stem of a modern common club-moss, made to show its vegetable cellular structure. Now, on comparing this latter with the coal section, it will not take long to recognize that the coal also contains remains of similar vegetable material, although in this instance probably ferns instead of club-mosses, yet stem and root sections and vegetable cells can be readily observed. We must, then, conclude that coal material is largely composed of the compressed remains of the leaves, stems, and roots of the various ferns, club-mosses, etc., of the period.

It frequently happens that these fossilized stems of plants

show their structure quite distinctly when magnified and seen in section. For example, the illustration (Fig. 128) shows the wood cells of part of a plant stem, although it is but a section

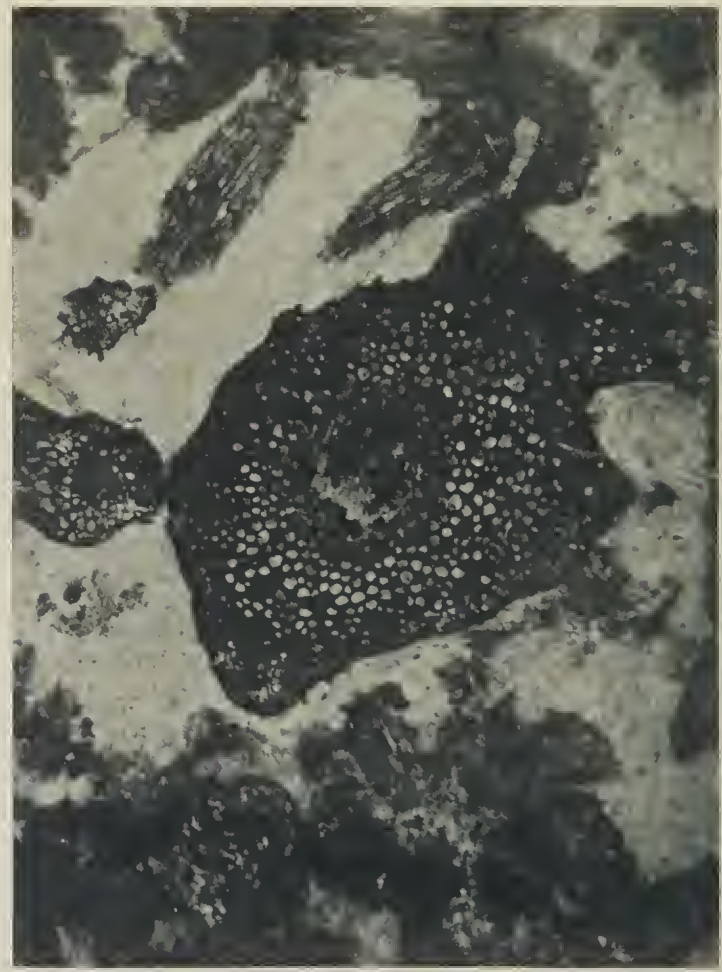

FIG. 126.—A thin section or slice of Yorkshire coal magnified to show how it is built up of vegetable remains.

through what is apparently stone; and we are able to say without doubt that the tiny cells were originally built up by a gradual plant growth, just as all growing plants are continually adding to their structures.

So it occurs, by making sections through the various kinds of coal, we are generally able to trace their vegetable origin from the softer vegetable and wood structures until these become saturated and consolidated, eventually losing their gaseous constituents, and becoming converted into carbonized

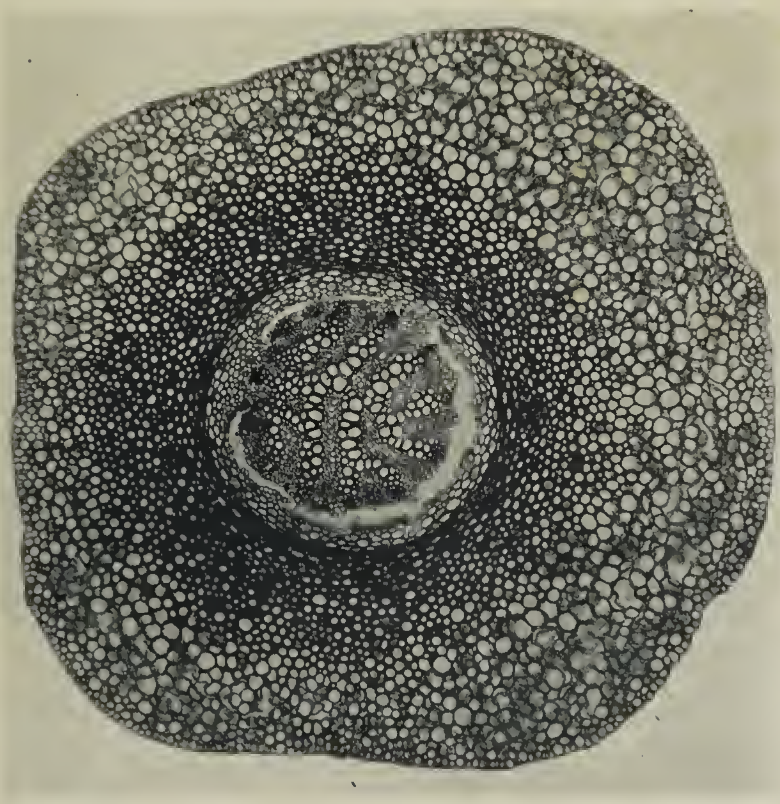

Fig. 127.—A section cut through the stem of a modern club-moss, to reveal its vegetable cellular structure—magnified fifty diameters.

coal of various degrees of purity, according as it approaches more and more closely to a pure form of carbon.

Fig. 129 shows vertical and transverse sections of fossil pinewood, while Fig. 130 shows another section of pinewood much nearer the coal stage. Again at Fig. 131 appears a section of lignite—a form of impure coal—while Figs. 132 and

N

133 represent longitudinal and transverse sections respectively of coal proper; the examples collectively illustrating how the

Fig. 128.—Part of section of a fossilized stem from a plant of the coal measures—magnified.

woody material has become converted into a carbon or coal stage, but still showing traces of vegetable origin.

Given, then, that coal is consolidated and carbonized vegetable matter, we have yet to find a reason which shall account for these vast beds of coal being buried so deep beneath the surface of the earth. And more than this, how is it that coal-fields are found beneath coal-fields, as in South

FIG. 129.—Vertical and transverse sections of fossil pine wood—magnified.

Wales, where no less than eighty distinct beds of coal have been recognized? Sometimes these beds are of great thickness, as in the instance of the famous bed of South Staffordshire, which was thirty feet in thickness.

We have glanced at the wonderful fossilized remains of the vegetation of the Carboniferous period, and seen how they

indicate that the forests of that time developed dense masses of vegetable growth, which, so far as quantity is concerned, would considerably surpass all our forests of the present day. For if the whole of the vegetation of our existing woodlands could be converted into coal, it would probably not make a

FIG. 130.—A section of fossil pine wood nearer the coal stage—magnified.

coal-field of more than two or three inches deep. And yet collectively the various seams in some coal areas would make a depth of two or three hundred feet.

From this we can estimate that these great forests of the coal period whose plants gathered in and stored these

enormous accumulations of carbon, were something almost beyond our imagination. For at present we know of no living things worth considering which are able to assimilate carbon from the atmosphere other than green plants.

As we have seen in a previous chapter, the green leaf

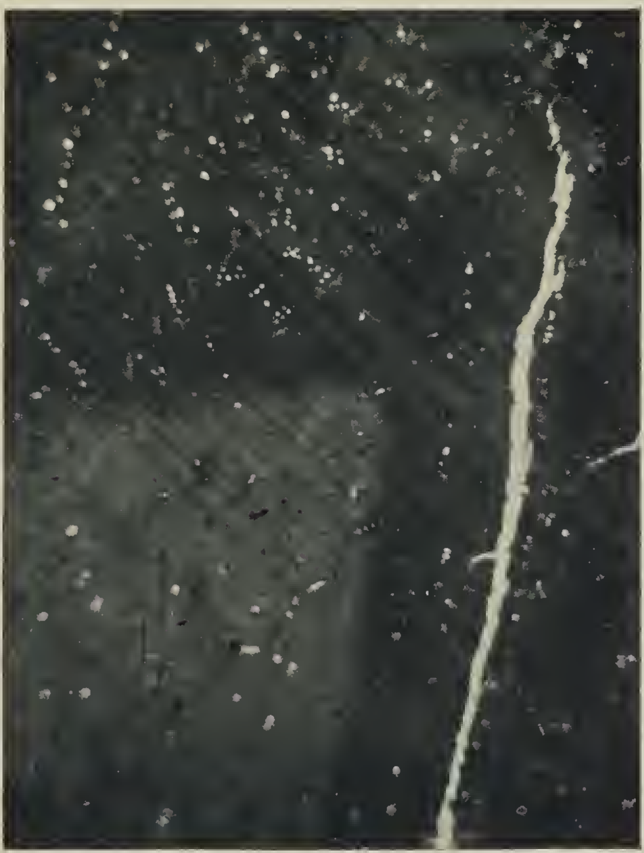

FIG. 131.—A section of lignite, a form of impure coal—magnified.

absorbs from the atmosphere the carbon dioxide or carbonic acid gas, which is built up of one part of carbon chemically united with two of oxygen. This is decomposed during sunlight in the chemical laboratory of the leaf, and the oxygen is given back to the atmosphere for animals to breathe and again

convert into this same carbonic acid gas; while the carbon is retained and built into the wood structure of the plant. And as all the myriads of plant-leaves of the great Carboniferous trees were continually catching and storing these particles of

FIG. 132.—Longitudinal section of coal, showing how it retains its wood-fibre texture—magnified.

carbon from the carbon dioxide of the atmosphere, which in those times probably existed in greater proportion in the atmosphere than it does to-day, it naturally follows that great and ever-increasing stores of carbon were being put by; not as

pure carbon alone, but chemically combined in the forms of starches, oils, etc., essential to plant growth.

But the earth at this time was in a very unsettled condition, and perhaps after these forests had grown and developed their trees and dense undergrowths for long periods of time, a slow

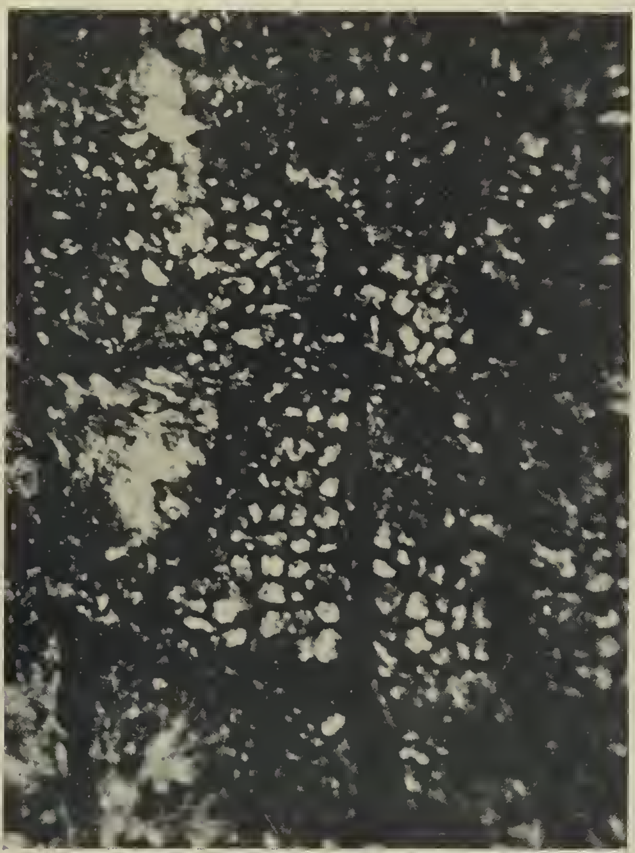

Fig. 133.—Transverse section of coal magnified.

and persistent subsidence of the land would take place. And as this sinking went on the tides would gradually carry in amongst these forests deposits of silt and mud, which would increase as time went on, until the once living and flourishing forest was completely submerged. And so a future coal-bed

was laid, which the ever-increasing weight above would, eventually, along with the natural chemical influences, convert into coal as we know it.

After a time the land would rest again, and the surface would become suitable once more for plant growth, and, in the course of time, a new forest would spring up, which in its turn would once more meet the same fate of submergence. And this again would be followed by others until we get coal stratum beneath coal stratum, each showing the same remarkable order—first a bed of clay, which represents the soil of the ancient forest; next the coal layer itself, representing the accumulations of the once living vegetation; and above this the deposits of sand and mud which have become hardened into shales and sandstones. A second time another layer of clay or soil follows, and over it coal and sandstone, the whole course of events to be similarly repeated time after time.

It has been truly and frequently remarked that our stores of coal represent so much fossil sunshine of the Carboniferous period. For the carbon gathered during the sunlight by the plants of this period constitutes the great and chief source of energy contained in coal; and the heat and light given out during combustion is but the warmth and light of the sun's rays absorbed ages ago by the leaves of the strange plants which we have been considering, reasserting itself, as it were, after lying dormant through countless ages.

And as we sit by our fireside and appreciate the glowing embers, while reading our newspaper or book with comfort and enjoyment, with our rooms illuminated primarily from this same source, and our surroundings further cheered by the innumerable æsthetic and useful products derived alike from coal, such as the lovely coal-tar colours, exquisite perfumes, and the jet, marbles, slates, and sandstones from the adjoining strata; not to mention the comforts derived from the numerous curative drugs that chemists have learned to compound from the coal-tar products, and not forgetting, too, that thence comes a sugar three hundred times sweeter than that obtained from the cane, we begin to realize how vast and foreseeing

are Nature's schemes. Indeed, the products and benefits man derives primarily from coal would require pages for their mere mention; for the Carboniferous strata were especially rich, like none before or after, and have yielded more for the progress and service of man than all the other geological systems put together; and, as I have mentioned in a previous chapter, although these great forests grew countless ages ago, apparently without any special purpose, yet on them the progress and social happiness of man to-day largely depend. Nature is one vast whole inseparably related and connected.

CHAPTER XI

The Life Story of the Lime Hawk-moth (*Smerinthus tiliæ*)

THE hawk-moths are amongst the largest and most handsome of British insects. The largest example found in England, and, in fact, in Europe, is the weird death's-head hawk-moth, with markings on the upper side of the thorax which curiously resemble a skull and cross-bones, and from which characteristic much unfounded superstition has arisen regarding this insect. One specimen of this hawk-moth in possession of the writer expands a good five inches across the fore-wings, and, doubtless, larger examples are to be found. The more familiar and common privet hawk-moth, whose handsomely coloured caterpillar feeds on the plant from which the insect derives its name, does not come far behind in size, one specimen in the writer's cabinet measuring four and a half inches across its expanded wings.

Such large wings naturally give these insects considerable powers of flight, and owing to their capabilities in this direction they have been regarded as analogous to the hawks amongst birds, and for this reason have been popularly called "hawk-moths."

One of the most common species is the beautiful lime hawk-moth, whose lovely hues of leaf-brown and bright olive-green—which vary immensely in different individuals—are always fascinating to the eyes of the observer. Especially is this so when the insect is found in its natural resting attitude

suspended from a branch by its fore-legs, and holding its body and wings well away from the object to which it is clinging. In this position the moth looks exceedingly like a partly withered leaf, its colours, of course, greatly assisting the resemblance.

The expanded wings of the lime hawk-moth rarely exceed three inches; yet when we observe one of these beautiful insects, and consider the extraordinary transformations through

Fig. 134.—Eggs of the lime hawk-moth deposited on the leaves and branches of lime tree—natural size.

which it has passed in acquiring that soft rich pile clothing its body, and those beautifully decorated wings — to be used, perhaps, but for a few hours while it seeks its mate, or (if a female insect) while she chooses suitable sites on which to deposit her eggs—we cannot but wonder at Nature's marvellous methods of attaining her ends.

Of course, everybody, in these days of Nature study, knows that a moth has first to be a caterpillar and then a chrysalis,

but how few people are really acquainted with the various metamorphoses in the development of even our most common insects. Let us, therefore, briefly review what takes place in the life history of the richly coloured lime hawk-moth, which may be taken—allowing for slight modifications in a few species—as typical of the development of the hawk-moths generally.

About the middle or end of June the female moth deposits

FIG. 135.—Two seven-days'-old larvæ of the lime hawk-moth resting along the veins of the lime leaf, where they are inconspicuous.

from a hundred and fifty to two hundred pale green eggs about the stems and leaves of the lime (Fig. 134), and other trees on which the larvæ feed. After ten to fourteen days the young caterpillars hatch out, and at once commence to feed, although at this stage they are, of course, very small and difficult to observe.

After feeding for a few days they begin to show appreciable

size. Illustration Fig. 135 shows two of these tiny larvæ when seven days old, holding to the veins of the underside of the leaf on which they are feeding. This habit of adhering to the veins of the leaves is characteristic of the young caterpillars of hawk-moths. They are seldom found on the stems or the upper surfaces of the leaves, and, doubtless, they obtain considerable protection from the attacks of birds and other

FIG. 136.—Larvæ sixteen and twenty-six days old—natural size.

enemies by this habit, their green colour and their form assimilating so perfectly with the veins as to make them quite inconspicuous.

The rate of growth of the caterpillars may be judged by illustration Fig. 136, where the smaller larvæ are sixteen days old and the two larger twenty-six. As they increase in size they moult their skins from time to time, developing a new

and loose skin in the place of the one which they have outgrown. At the end of about forty days the caterpillars are full

FIG. 137.—Full-grown larvæ feeding—natural size.

grown (Fig. 137), and their bodies then present a granulated and wrinkled appearance, coloured green, with oblique lateral

FIG. 138.—A full-fed larva viewing the ground before becoming a pupa.

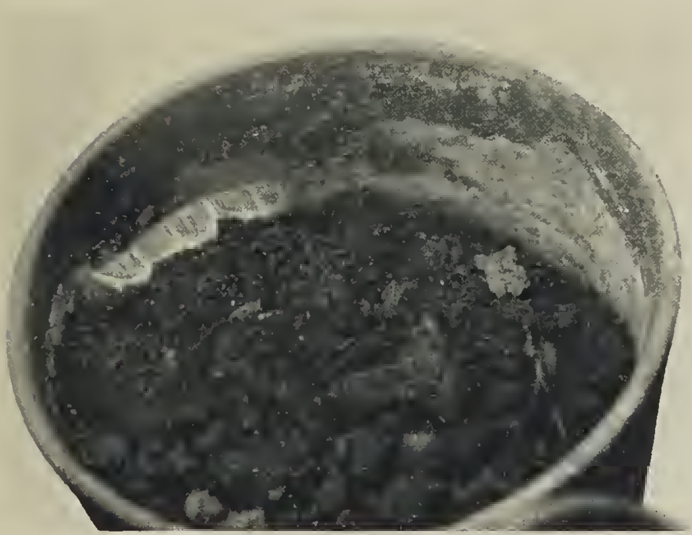

FIG. 139.—A suitable spot found at last.

FIG. 140.—Winding its way beneath the soil.

FIG. 141.—"Good-bye till next year." The white cross marks the spot where the larva has disappeared.

streaks of a pink shade, while a blue curved horn has developed at their tail-end.

After this forty days' feeding period—for the grub devotes the whole time entirely to seeking and devouring green leaves and to resting—the caterpillar prepares for its next great change or metamorphosis. Its voracious appetite declines, and it turns from the green leaves and works its way down the

FIG. 142.—The pupa, or chrysalis, beneath the soil.

branches to the trunk of the tree, eventually reaching the soil below.

In illustration Fig. 138 is shown a full-fed captive caterpillar, which I provided with a tree-pot full of soil for its further development. For an hour or more it refused the soil as if suspicious that something was wrong, making continual tours round the outside rim of the pot. Eventually, however,

it seemed to arrive at the conclusion that there was no end to this journey, and once again got back on to the soil, and here, after first testing almost every bit of the surface, it made the best of things, and in about three or four minutes quietly disappeared from view (see Figs. 139, 140, 141).

In the ordinary way we cannot, of course, see what takes

FIG. 143.—The wings freeing themselves from the body after the moth has left its chrysalis beneath the soil.

place beneath the surface of the soil, but if we carefully unearth the developing insect about a fortnight after its disappearance, we find, often at a depth of twelve inches or more, a rounded cavity or chamber, in which rests a dull brown chrysalis or pupa (Fig. 142). This excavation the caterpillar forms by pressure from its body, assisted by its rough and rasp-like skin, working

round and round within the chamber until that is sufficiently large to comfortably accommodate its pupa.

When the caterpillar has finished making the excavation for its pupa period, it rests lying on its back within it, and in the course of a few days moults its last caterpillar skin; and when this breaks away, we have, instead of a caterpillar, a horny

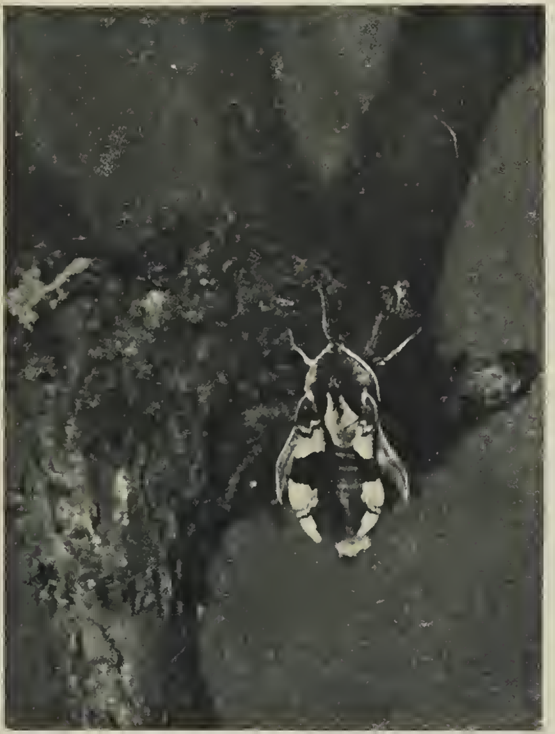

FIG. 144.—The lower pair of wings beginning to develop.

chrysalis like that shown in Fig. 142. In this chamber beneath the soil the chrysalis rests from about the middle of August, throughout autumn, winter, and spring, until, perhaps, May or June of the next year. In the example illustrated the caterpillar entered the soil on August 8, and appeared again as a perfect moth on April 30 of the following year.

Within this hardened pupa-case or chrysalis beneath the sodden earth, throughout the autumn, winter, and spring

Nature slowly matures the perfect and delicately clothed insect that we know as the lime hawk-moth; its velvet-like pile, lovely colours, and handsome wings are all perfected in some wonderful and mysterious manner within this horny shell as it rests in its chamber a foot or eighteen inches beneath the surface of the soil.

FIG. 145.—Lengthening out.

In due course the eventful day arrives when the insect makes its final moult; and this time it is not a caterpillar skin that is cast, but the hard pupa-case or chrysalis. This splits near the head of the enclosed moth, which then quickly breaks through the opening and emerges into the cavity it formed eight or nine months before, when in its caterpillar stage. And then a most wonderful and extraordinary journey to the surface of

the soil is made. Most wonderful because, though the moth is so delicately clothed that the least touch will damage its beautifully adorned wings and body, yet by some mysterious aptitude it is able to force its way through a foot or more of rough soil until it crawls out into the air with wet and limp wings, but withal as perfect and unsullied as the newly opened

FIG. 146.—The wings more than half developed.

bloom of the lily, although those richly coloured wings have yet to reach perfection.

On arriving above ground the moth still retains the impress of the chrysalis in which it has been evolved, its wings adhering to its body and giving it a strange appearance as it crawls rapidly to a tree-trunk or similar object on which it can expand and dry its wings. Here its organs of flight slowly develop;

Fig. 143 shows them just freeing themselves from the insect's body. Fig. 144 was photographed fourteen minutes later, and in this the lower pair of wings can be seen just shaking from their folds. When the lower wings get free, development becomes more rapid; Fig. 145 shows the progress made ten minutes later, and Fig. 146 three minutes later still. In

Fig. 147.—Four minutes later they have nearly completed their development.

Fig. 147, which was photographed four minutes after that shown in Fig. 146, the wings are seen to have nearly completed their development. It was ten minutes later, however, before they had lengthened out to their full extent; and in Fig. 148 the moth is shown suspended by its legs, with fully developed wings, waiting until they dry and come under muscular control. This latter event took place one

hour and ten minutes afterwards, when the moth flapped its wings and exposed the lovely colours of their upper surfaces, and then settled down into its natural resting attitude (Fig. 149).

And so from the tiny egg, then, the ever-hungry caterpillar, and finally the dormant chrysalis buried beneath the ground,

FIG. 148.—Completed and drying.

is evolved the handsome lime hawk-moth; which rests until darkness approaches, and then takes to its beautiful wings to seek its mate. Soon after mating the female insect becomes inactive and deposits her batch of eggs, and either dies immediately afterwards, or lingers a sluggish existence for a day or two, rarely again flying; and as the mating not infrequently takes place soon after the moths commence to fly, their

wonderful wings and colours may have but a very short existence, yet they have served their purpose in regeneration for which Nature so carefully and marvellously wrought them.

FIG. 149.—Wings under muscular control, and ready for flight.

CHAPTER XII

The Life Story of the Wheat "Mildew" (*Puccinia graminis*)

THE mere thought of the above-mentioned agricultural pest is almost sufficient to make the farmer feel uncomfortable. However, there is one consoling point with regard to this, and similarly troublesome parasitic diseases, which is that the organisms producing them possess extraordinarily complicated life histories. So complicated are they, in fact, that where one disease-conveying parasite is able to complete its life functions, and multiply its species, unnumbered thousands of others perish in the effort.

Nature, for some mysterious reason which she understands best, allows many injurious and—from man's point of view—undesirable organisms to live and propagate their kind. Plants have to struggle against innumerable parasites which are always ready to attack a weak spot, and amongst those which harass our cereal plants the wheat or corn "mildew" stands pre-eminent.

Late in the summer or autumn the "completed spores" of this parasitic fungus are formed from mycelial strands (the vegetative parts of the fungus) just beneath the surface tissues of the wheat plant, producing black or brown irregular lines about the yellow straw and brown leaves. These black streaks are built up of clusters of two-celled bodies, or spores, carried on a short stalk. A magnified section of wheat stalk is shown in Fig. 150 with these clusters of *teleutospores*, or "completed

spores," *in situ*, while Fig. 151 shows some others more highly magnified. These constitute the mature "mildew," and are resting or winter spores, which do not fall, but remain attached to the host-plant throughout the winter.

During the following spring each of the two-celled *teleutospores* throws out a slender thread-like structure, which

FIG. 150.—Corn "mildew" on section of wheat stem, showing the clusters of two-celled winter spores—magnified.

eventually develops at its apex four single spores. Then comes the remarkable circumstance that before these newly formed spores can germinate they must reach a leaf of the barberry bush, otherwise they will perish. Provided that a barberry shrub is in the neighbourhood, and that one of these spores gets carried by the wind, or conveyed by animal or insect agency, to it, the spore at once commences to germinate on the

leaf, producing interwoven thread-like tissues which penetrate its structure. Eventually other reproductive bodies are formed, orange coloured spores known as *æcidiospores.* These are contained in cup-shaped structures, or "cluster-cups," embedded in the tissues of the leaf, which, when mature, burst through the epidermal cells, and pour out their numerous spores, which are formed in long rows or chains, the surface skin of the leaf forming a fringe around the mouths of the cups. Fig. 152

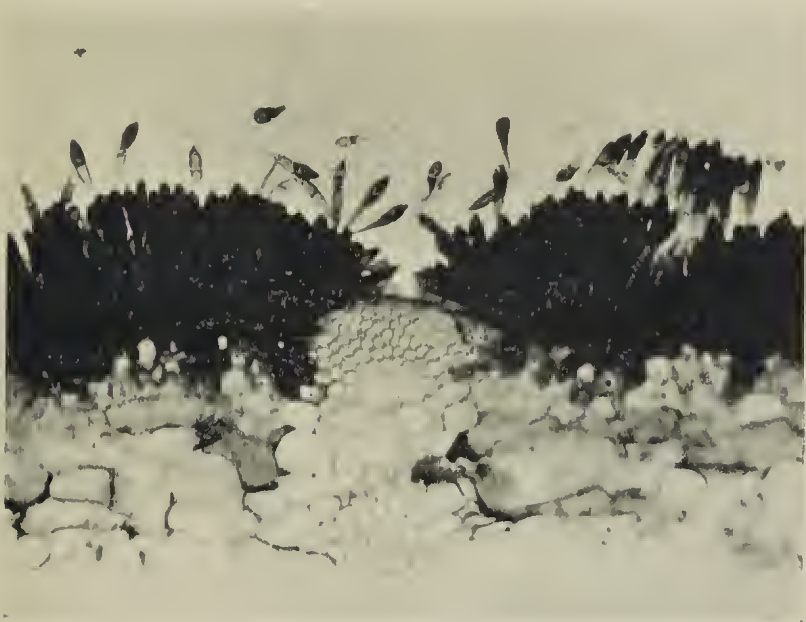

Fig. 151.—A further magnified view of the two-celled spores of the wheat "mildew."

illustrates a section cut through a leaf showing these cluster-cups containing their numerous spores in various stages of their development. Two will be seen to have completely ruptured the enclosing leaf tissues, while the remaining two show intermediate stages, one having yet to break its way through. It should be understood that it is the lower side of the leaves that the cluster-cups attack.

These numerous *æcidiospores* are then scattered broadcast,

and soon reach their final hosts—the grasses, wheat, rye, oats, etc. Here they again germinate, but during the early summer do not directly produce the two-celled *teleutospores* from which they primarily originated, and which stand through the winter. Instead, some one-celled spores known as *uredospores*, or "blight spores" are developed (Fig. 153), which have the power to germinate at once on grasses, and constantly reproduce their kind without passing through the barberry stage.

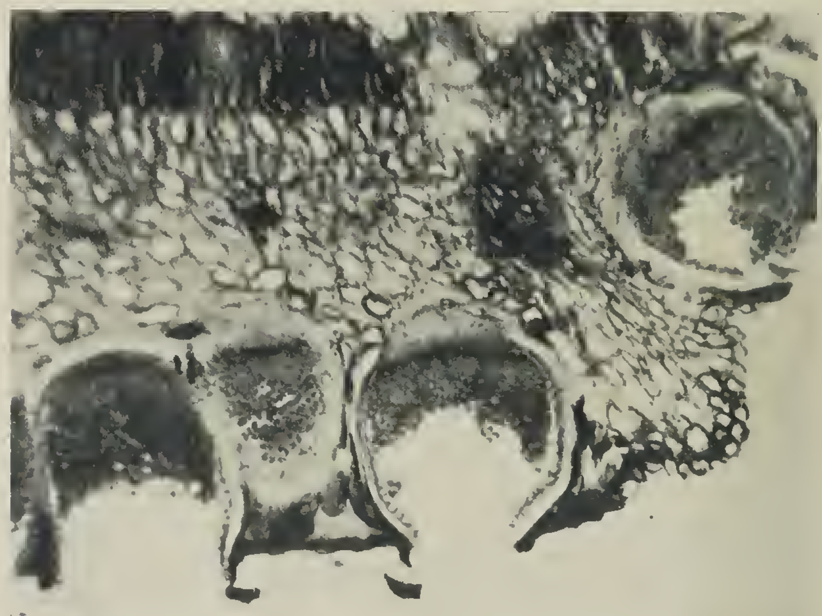

Fig. 152.—Section of cluster-cups on the underside of barberry leaf—magnified.

Naturally, these spread the fungus rapidly during the growing season, as they have no complications in their life-cycle. Subsequently, however, as autumn draws near, these *uredospores* give place to the *teleutospores* again, which tide the fungus through the winter, and which will need the barberry leaves for their development in the following spring.

It is clear, then, that the "mildew" fungus cannot continue its development on the one host, but requires the barberry and grasses to complete its life functions. In this it is analogous

to similar parasites that prey upon the higher animals, as, for example, the liver-fluke which attacks sheep, and causes the terrible disease known as the "rot," which organism requires for its hosts the sheep and a certain species of fresh-water snail; or, again, the deadly malarial parasite which attacks man in tropical climates, and which requires not only man, but also the mosquito for its host. These animals may seem widely removed from each other; but the botanist will tell us

FIG. 153.—The one-celled "blight-spores" of the wheat "mildew" shown *in situ* on section of leaf—magnified.

that the barberry and grasses are also widely removed in the vegetable world.

Again, this example of the "mildew" is not exceptional or unique, for there are many other known instances of fungi that require more than one of the higher plants as hosts on which to complete their development. One form produces its one-celled *uredospores* and its two-celled *teleutospores* on the common groundsel, and its cluster-cups and *æcidiospores* on the pine tree; another its *teleutospores* on juniper bushes and

its cluster-cups on the mountain ash. The red cedar and various fruit trees also play alternate hosts to another similar fungus. Others of these parasites are less complicated in their development, and produce their various reproductive spores successively on one plant; while some more simple forms

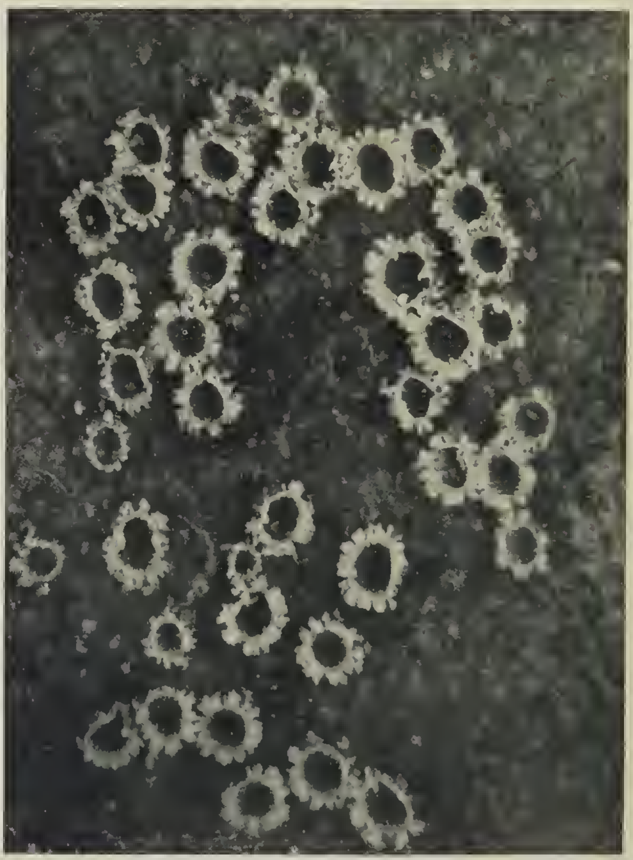

FIG. 154.—Cluster-cups on leaf of the common field daisy—magnified.

possess only *teleutospores*, or these and one of the other forms. The *æcidia*, or cluster-cups, are common on numerous plants, and I have illustrated a group of these from the under side of the leaf of the familiar field daisy, as seen in surface view in Fig. 154, and another from the leaf of the lesser celandine in

Fig. 155. The former I gathered in a moist meadow on December 31, and they are undoubtedly the prettiest cluster-cups amongst many that I have examined. Of course, they are very small objects; but when viewed beneath the microscope, their white-fringed cups, crowded inside with yellow

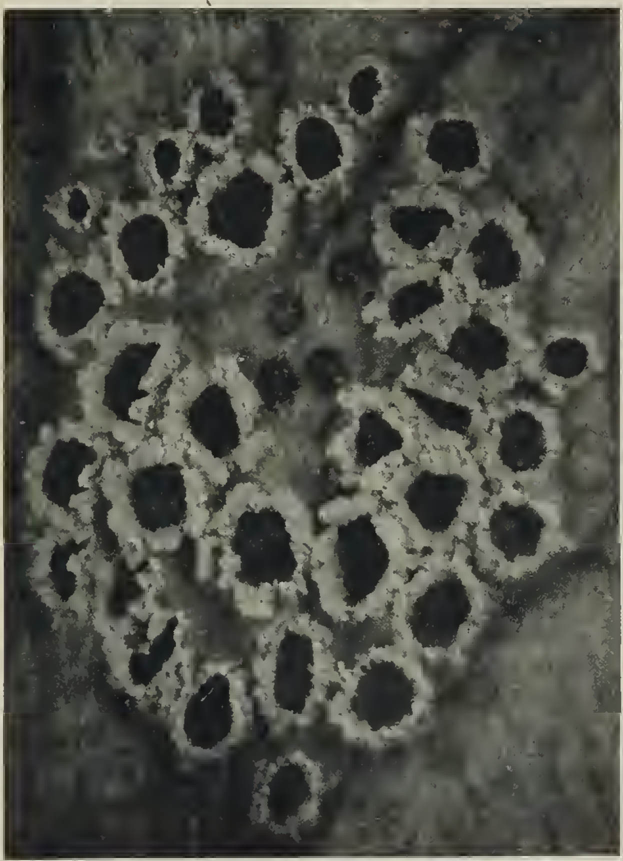

Fig. 155.—Cluster-cups on leaf of the lesser celandine—magnified.

spores, all standing on the green background of the leaf, remind one of a field of the blossoms of the plant on whose leaves the pretty parasite is found.

CHAPTER XIII

The Life Story of the Peach-blossom Moth (*Thyatira batis*)

THE date was June 21 (the year need not concern us), and it was about three o'clock in the afternoon. Miss Peach-blossom had in some mysterious manner suddenly become possessed of wings. How she got them she did not know—and most probably she never thought of the matter at all. In fact, her attentions were entirely concentrated upon the future, and, although her wings were limp and wet and altogether useless for flight, yet she seemed most hopeful about them. She arranged herself beneath a bramble stem so that the wet wings hung down fully extended by their own weight, and in this attitude she rested for more than an hour. Then she fluttered her newly acquired organs, just slightly at first, but more forcibly a moment later when she realized they had dried rigid, and that she could manipulate them. Finally she reversed them and exposed their upper surfaces, revealing as she did so their greenish-brown colour prettily marked on the fore-wings with bold spots of rosy pink—indeed, her poetical name was derived from the fact that these spots resemble the fallen petals of the peach-blossom.

After she had arranged her toilet and spread out her pretty wings in the most effective manner above her body, she became perfectly still. Probably she slept for a while, or may be she was dreaming of a great project she had in mind ; at all events darkness had almost set in when she roused herself, and then,

without the slightest warning of her intentions, she ran swiftly up the bramble stem until she reached its topmost point, and pushing off from this she launched herself into space.

Away she went over the bushes and amongst the trees, finding her wings even more fascinating organs of locomotion than ever she had dreamed of. At last she found herself in an open glade in a wood, where the large trees kept away the cool wind without obstructing her progress. So along this glade she fluttered, delighted with the calm air and the fascination of her flight.

It was just at this moment, though, that Miss Peach-blossom almost came to grief. Her flight seemed to give her a wonderful appetite, and, as she passed above the bushes, odours of sweet flowers were so many and various that she scarcely knew which nectar seemed the most attractive means to quench her thirst. While still undecided, she dashed towards the trunk of a large oak tree from which a strong perfume of an attractive nature was arising, and as she neared this she found many moths of various kinds fluttering round about. In another moment she would have been sipping some of the sticky and strongly scented liquid which looked so tempting in the darkness as it adhered to the rough bark of the tree. However, Nature had another purpose in view for Miss Peach-blossom than decorating the cabinet of the entomologist. For, although she did not know it, this was a decoy—the "sugar" (a mixture of treacle and rum) of the entomologist, which first attracts the insects by its strong scent and afterwards holds them captive by its sweetness. In this sweetness, however, lies danger, for the liquor that thus attracts the insects by its strong sweet smell, soon stupifies and intoxicates them, so that they become easy prey to the collector who comes along later with his lantern and "killing-bottle."

How was it, then, that Miss Peach-blossom in the height of her exuberance did not reach the dangerous liquid on the tree trunk after dashing towards it? Well, it happened like this. Just as she went towards the "sugar" she collided with another peach-blossom moth which had likewise been deluded towards

it. The two moths then fluttered away from the "sugar" for a moment into the air, and while they were there they discovered a far greater attraction than the entomologist's "sugar." In fact, although there were many trees beyond this first one all carefully "sugared," yet none of these now had the least

FIG. 156.—The whole thing was settled on a bramble leaf. Miss Peach-blossom decided, then and there, to become Mrs. Peach-blossom.

attraction for either of the moths; indeed, they flew away together in the opposite direction, right out of the danger zone.

The whole thing was settled on a bramble leaf (Fig. 156). Miss Peach-blossom decided there and then to become Mrs. Peach-blossom; so a honeymoon was commenced.

The honeymoon did not last very long; in fact, the following night Mrs. Peach-blossom had quite other occupations to divert her. She set out just at dusk again (her mate was not with her), but she did not fly very far, and eventually she alighted upon a bramble twig. For a few moments she care-

FIG. 157.—The peach-blossom moth has quite artistic notions about egg-depositing, and frequently places them in couples on the tops of bramble prickles.

fully scrutinized the twig up and down, then, commencing low down, she worked upwards, visiting nearly every prickle on the twig in its turn, even not forgetting the prickles of a leaf on the twig. When she had completed this work the twig presented a rather curious appearance (Fig. 157), for on every prickle, more or less, was carefully placed one, or a couple, of her

tiny white eggs. Why she placed them in such curious situations is difficult to understand; doubtless she thought them best out of danger there. As if to vary the proceedings somewhat, she deposited some more of her eggs on the serrated points of the edges of some of the leaves (Fig. 158).

FIG. 158.—Occasionally, as a little variation, the moth deposits some of its eggs on the serrated points of the leaves.

In illustration Fig. 159 is shown two of the tiny eggs attached to the tip of one of the prickles as they are seen through the pocket lens of the writer. It will here be seen how beautifully decorated are the shells, with longitudinal ribs, between which is delicate lattice work.

In due course all these tiny and wonderful eggs are satisfactorily deposited, and the moth then has fulfilled the functions for which Nature provided it with its pretty greenish-brown

and pink-spotted wings. Its duties in life cease soon afterwards; for both male and female insects perish after mating has taken place. This, from the human standpoint, seems sad when we think that their perfection has been reached only but a few hours before. Perhaps, however, those insects that live to reach perfection and perpetuate their species, have lived

FIG. 159.—A microscopic view of two of the eggs on the top of a prickle.

a full life—a life equivalent, it may be, to the four score years of human life.

In the course of about a week (June 28), all the shells of the tiny eggs at the tips of the prickles and at the edges of the leaves burst open. Out of the opening in each egg came a baby caterpillar, which quickly made its way to the edge of a leaf, where it at once commenced to feed, biting off the sharp tips of the serrations and working its way towards the centre of the leaf. In the course of a few days,

although the caterpillar was small, yet its persistent work upon the leaf tissues gave considerable evidence of its existence (Fig. 160).

By July 18, the caterpillar had devoured as many bramble leaves as it needed to carry it through the next stage of its

FIG. 160.—The presence of the young larvæ may be readily detected on the bramble leaves.

existence, when it would have no opportunity of feeding. At this stage it had developed into quite a handsome larva, with a velvety skin beautifully coloured with rich greens, greys, and browns, the colours forming quite artistic shadings as the caterpillar moved about amongst the leaves (Fig. 161).

The next thing that happened was the disappearance of this handsome larva; for having no further desire to devour bramble leaves, it utilized them in another way, viz. by threading several of them together with silken threads that it spun for this purpose from silk glands beneath its head.

FIG. 161.—The larvæ have velvety skins, richly variegated and marbled with brown, green, and grey.

When it had managed this successfully, it ensconced itself comfortably between the folds of these leaves and then slowly pulled them closer together, thus forming for itself a loose cocoon (Fig. 162); and so the caterpillar disappeared from view, and thus terminated its caterpillar life.

If, a few days later, we had pulled aside the leaves the caterpillar had so diligently stitched together, we should not have found our caterpillar within. Instead, we should have met with a curious brown pupa or chrysalis (like that shown in illustration Fig. 162). However, if we had looked

Fig. 162.—The caterpillar attaches one or more leaves together by means of silken threads to form its cocoon. In the lowermost cocoon the chrysalis is exposed to view.

carefully into this cocoon, we should doubtless have seen a little shrunken ball of skin, and if we had spread this out, it would become plain to us that it was the skin of the caterpillar. In the course of its growth the caterpillar had moulted its coloured skins several times as it successively grew too large

for them, and with each moulting appeared with a new and more brightly coloured suit; but this last moult had not produced a caterpillar skin at all, but this curious, brown, horny covering that enclosed the dormant pupa.

Nineteen days after the caterpillar disappeared (August 5), another even more marvellous moulting of the skin took place, for the brown, horny chrysalis shell was itself thrown off. Then, through one of the openings of the loosely arranged cocoon, a little feathered head with a pair of twitching feelers and large black eyes appeared, quickly followed by a body bearing curious dumpy wings. It somewhat resembled a moth, it is true, but it bore such a quaint appearance as to make one wonder whether it was really a moth or some "freak" such as Nature occasionally produces. But this strange insect pursued its way most actively up the branches, and at last came to rest beneath a leaf-stalk, to which it remained clinging by means of its legs.

There it hung beneath the leaf, and—there was no possible doubt about it—as it hung, its wings grew gradually larger. These dwarfed and dumpy apologies for wings slowly developed rich shaded brown hues as they lengthened out, but we could not see their upper surfaces, for these were closed together.

While the moth remained suspended there, it brought forcibly to mind that other moth which but a little more than six weeks before had suddenly found itself possessed of wings. Here also was a moth which had suddenly appeared to the world and apparently grown two pairs of wings before our very eyes; although it had in reality only shaken these organs from the folds into which they had been pressed within the chrysalis.

Then our moth surprised us once again, for while we had been musing its wings had dried, and now it tried to exercise them by flapping and fluttering them. At last it succeeded in opening them out and exposing their upper surfaces. At once there appeared to view the greenish golden-brown colour and the rosy petal-like spots of the moth that had charmed us some six weeks before as it rested, while it anticipated (as we

imagined) the great things it would accomplish when night came on and its wings were dry. Yes, this newly developed moth was a perfect likeness of its parent.

In a few hours' time this moth, too, would advance into its new sphere of life, and glide over hedgerow, field, and woodland. It would also take the same risks of the "sugar" decoy of the entomologist, and other more natural foes. And most probably it would find a mate, just as quickly as its parent did before it, and then, like her, it would drop out from the scene of life.

Finally, there remains to record one great difference between the first moth and the offspring whose life scenes we have here glanced at. The offspring we observed occupied scarcely more than five weeks to complete its existence in all its stages from egg to fully developed insect. Its parent, however, needed a much longer period, and likewise will its offspring, for these will attain the pupal or chrysalis stage about the middle of September, and then if we add to this the nineteen days, or thereabouts, of the dormant pupal period, we have reached a time when frosts and cold begin to make themselves felt.

If the moths appeared at this time, while they might finish their own lives successfully, yet what of their offspring to follow? Nature does not take the risk, but bids the moths within the chrysalides to lie by until wet, cold, and frosts have disappeared. Their time is due about June of the following summer, when they crawl from their cocoons (which in the autumn brood are often made amongst fallen leaves upon the ground) to become the parents of the midsummer brood; thus while one generation occupies only five weeks for its complete development, the other may occupy nine months, although the active life period of both generations is about the same. It is possible, too, that in very favourable seasons a third brood may be successfully reared, but the winter is always spent in the pupal stage.

CHAPTER XIV

The Story of the Senses of Insects

INSECTS as a class of animals outnumber in species all the other groups of land animals put together. This, of course, means that, in the "struggle for existence," they have been eminently successful; in fact, insects have not only held their own, but have shown a startling pre-eminence all along the line of developing and advancing life-forms. It also follows that we may expect to find highly evolved sense organs amongst this successful class of animals. However, immediately we commence to consider the senses and sense organs of insects, unexpected difficulties begin to arise in all directions. Fabricius, the distinguished Danish naturalist, well said that "nothing in natural history is more abstruse and difficult than an accurate description of the senses of animals"; and this particularly applies to the class we designate "insects."

The difficulty of the subject arises from the fact that while insects and man are both highly specialized animals, their specialization has been evolved on lines so different that it is now almost useless to make comparisons between them. When we attempt to interpret the senses of insects by comparison with our own, and by reasoning from analogy, we discover, in spite of certain superficial resemblances, other aspects of such senses, and other special senses which completely baffle our understanding, because we ourselves possess nothing analogous to them. Likewise with the sense organs, these are often very problematic, bearing little or no resemblance

to our own; and seeing that they minister to different functions, there is, of course, no reason why they should.

It may at first seem an easy matter to decide whether an animal can see or hear, but to definitely prove it is quite another and much more difficult matter. The common earthworm, for example, is, so far as we can discover, entirely devoid of eyes, yet we have only to approach it with the light of a lantern at night, when it is extended from its burrow, to cause it to instantly retreat and withdraw from our sight. What sense within the worm is influenced by the light, and warns it of approaching danger, we cannot judge by analogy with our own senses. In our case it would have been the sense of sight possessed by the eye (an organ which, as we have seen, the worm does not possess) that would direct our action. Bats, too, although of nocturnal habits, yet possess very small eyes, and it has been proved that when their eyes are covered, or even completely destroyed, they are still able to continue their flight and steer their way even through a maze of threads, through a small hole in a curtain, or along a winding cavern, back to their dwelling-holes. There is reason to think that these creatures are directed by curious structures known as Pacinian bodies, which are delicately sensitive to air pressure, and are found abundantly in the wing-membranes. We might, therefore, say that the bat finds its way by means of the sense of touch, not, as we do, by the sense of sight.

I have mentioned the two foregoing instances of familiar animals outside the realm of insect life to demonstrate that to trust to analogy alone in comparing the senses of other animals with our own may often be very misleading. This is especially the case in regard to insect life. We must not suppose, for example, that because a butterfly takes flight as we approach it, it has necessarily seen us coming, or even that it has heard us; slight changes in the currents of air may have affected some of its problematic organs of sense, and it may have *felt* us approaching; in the same manner probably as the bat in its flight is able to avoid objects in its way.

The subject of the senses of insects is a vast one, to which,

during the past century, many eminent naturalists in various countries have devoted long study and investigation; yet, in spite of all their labours (so intricate and involved is the subject), we have to-day but very little definite knowledge upon the matter, and have to rest contented with plausible suggestions adduced from the weight of evidence, which may be only approximations to the truth.

I propose now to deal briefly with a few aspects of this wide subject under the familiar headings of Touch, Taste, Smell, Hearing, and Sight.

Touch

The sense of touch in insects will need but little comment, as it is not readily distinguished from their other senses. With us the skin is the tactile organ, and stimuli, such as mechanical pressure or heat-rays, affect fine nerve-fibres terminating amongst the surface cells of the skin. But, in insects, the inner or sensitive skin is covered with a more or less hardened and thickened layer of chitine—a beetle presents a familiar example. This strong external covering, naturally, prevents the reception of stimuli by the sensitive dermis. We find, however, that numerous pores exist in this chitinous investment, and under each pore lies a sense-cell, from which springs a tactile bristle for contact with external bodies. This accounts for the numerous hairs we find on the bodies and limbs of insects; indeed, all the senses of insects, excepting that of sight, are controlled by variously modified hair structures, and it is a fact that any given part of an insect's anatomy may contain numerous hairs, quite different in character, and all serving distinct sense functions. On the proboscis or tongue of a fly, for example (Fig. 163), four kinds of hairs have been recognized. However, while we may distinguish the differences in these various hair structures, and recognize their relationship with nerve-cells (which, of course, implies sensory functions), the difficulty is to connect any individual class of hair with its particular sense function,—to say whether a given hair

serves for touch, taste, smell, or hearing. It is here that

FIG. 163.—The proboscis or tongue of a fly, on which four kinds of hairs are recognized, and all of which probably serve different sensory functions.

the differences of opinion arise, and that the experts disagree, so slight is our knowledge of the real means and

organs by which the senses of insects and other animals are affected.

More complicated and active organs of touch are witnessed in the antennæ or "feelers" of insects; and although the popular term "feelers" is very suggestive of the sense of touch, and insects are not infrequently seen using these organs as if they were feeling the object with which they are in contact, yet the antennæ must not be looked upon as tactile organs only. While they may serve the sense of touch, yet it is practically certain that they also possess other much more important sensory functions, as I will endeavour to show later.

Taste

That insects possess a sense of taste is very obvious to all who study their habits. A striking instance of this sense is exhibited by caterpillars, nearly every insect larva selecting that particular plant which provides the special food it requires, though some caterpillars are very indiscriminate feeders, and prey upon quite a variety of plants. Yet even these general feeders restrict their attentions to a particular assortment of plants, entirely avoiding certain species. On the other hand, there are caterpillars that are most fastidious in their tastes, and will starve rather than feed upon a plant other than that of their special selection. An instance of this kind came under my notice recently when feeding up some larvæ of the familiar brimstone butterfly. These caterpillars feed on the two common British species of buckthorn (Fig. 87), but as another closely allied species (but not British) grew near, I provided the young larvæ, just hatched from the egg, with this foreign species to feed upon. Some days afterwards I found that most of them had starved, and the others would have undoubtedly done the same had I not obtained for them the particular species of buckthorn on which their ancestors had fed long before them. Thus I had proof of the very remarkable fact that these hungry caterpillars would starve rather than feed upon a plant so nearly related to, but

not precisely the same as, their usual food. To suppose an analogous case in regard to human beings, is it conceivable that a man would starve rather than eat a kind of cabbage not quite like that he was accustomed to? This instance tends to show that the sense of taste in this particular caterpillar must be highly specialized. A change of food material when caterpillars are half grown will often cause them to turn from it; yet they will frequently take to a new food if it is given them just when they leave the egg.

We usually associate caterpillars with a green food diet, but let me cite another instance to show further how the taste of these infant insects may differ. There are two British caterpillars, both commonly found on oak trees, which eventually become the satellite and dun-bar moths, and these larvæ are both confirmed cannibals, hiding from and stalking their prey, which they attack from behind. I have seen a larva of the dun-bar moth devour all but the hard parts of the head of a neighbouring caterpillar at least two-thirds its own size, in a little under an hour.

Even amongst butterflies, too, taste differs very largely. We generally think of these insects as sipping the sweet nectar of flowers, but some species have very loathsome appetites. For example, the majestic purple emperor butterfly (Fig. 164—perhaps the most beautiful of British butterflies) is tempted from the lofty heights above the tree-tops at which he soars to feast at a filthy puddle, or more particularly upon the putrefying carcase of a dead rabbit, stoat, weasel, or cat. And, although unapproachable at other times, yet, when feasting upon these substances, its sense of taste seems to completely obliterate its other faculties, for you may approach and even touch it then without disturbing it, so absorbed in the feast does it become.

Another familiar instance of specialized taste amongst insects is that of the green-fly or "blight." The green-fly that infests the rose tree is not the same species as that which infests the hop or vine. Indeed, there are individual species for the apple, plum, peach, cherry, hazel, dahlia, honeysuckle,

radish, nettle, thistle, and innumerable other plants besides. Then, again, we may turn from plant to animal parasites. The flea is a familiar example, of which a hundred or more kinds are known to infest mammals and birds; yet each of these,

FIG. 164.—The beautiful purple emperor butterfly, whose taste is so depraved that it feasts at filthy puddles, or upon the putrefying carcase of a dead animal.

more or less severely, restricts its attentions to its particular host. Thus man, bat, dog, cat, mole, squirrel, hedgehog, fowl, pigeon, and many other animals, possess each its own specific kind of flea, and each one of these fleas has a sufficiently

distinct individuality for the man of science to declare on what particular animal it preys.

It has been shown, too, that ants and bees will commence to feed upon honey that has been mixed with distasteful substances, if these substances are inodorous, but that they quickly find out the trick, and endeavour to remove the distasteful properties from their mouths. We may conclude, therefore, that insects, like ourselves, have well-developed organs of taste, and that these are, probably, some modified form of hair structure, such as those referred to when dealing with the sense of touch, and situated in or near the mouth parts.

Smell

We come now to the "distance senses"—senses associated with information about objects at a greater or less distance, and therefore in marked contrast to those of touch and taste.

That some insects possess a keen sense of smell no one can doubt. It seems highly probable, indeed, that this sense is much more developed in insects than in man, although we cannot be absolutely sure on this point, because they may possess other senses that supplement that of smell—senses which we ourselves do not possess and of which we cannot, therefore, have any adequate conception.

Let us take a concrete example. It is a familiar fact to entomologists that the males amongst many species of moths are strongly attracted by a female of their kind that has just emerged from the chrysalis. If the female insect be placed in a box with a gauze covering, and carried into a wood or some other suitable locality, a crowd of male suitors almost immediately "assembles," all madly in love, and running recklessly up and down the gauze covering in frantic eagerness to get closer to the object of their adoration. But for this test with the female insect, the entomologist might never have known that this particular species of moth frequented the neighbourhood. However, no sooner is the female moth introduced than a male moth appears, often quickly followed by many others, sometimes two and three arriving together.

How were these males attracted? It has been suggested that they possess a very acute sense of smell, and so are drawn towards their desired bride. While this assumption is probably correct, yet we cannot ourselves detect any smell even when close to the female moth, yet these male insects may come from quite considerable distances to find the hidden inmate of the box. Assuming that it is a sense of smell that is affected, it is obvious that it must be altogether

FIG. 165.—Part of the feathery antenna of the pale tussock moth, showing its sensitive bristles, probably organs of smell. The moth is shown above at about one-half of natural size.

different from, and much more delicate than, that possessed by man.

We have some evidence that these actions are owing to a sense of smell in the fact that the male moths of those species which "assemble" have large, feathery antennæ, clothed with sensitive bristles (Fig. 165), while the corresponding organs in the females are much more simple in structure, and there are weighty reasons for regarding the antennæ as the seat of the organs of smell. There is also the fact that some of these

insects take their last meal in their caterpillar stage, the mouth parts being more or less atrophied in the moth state, and this necessarily makes the courtship brief; hence, too, the necessity for these highly developed olfactory organs (if such they are) to assist the males in finding their mates quickly. Also, in some species the female insects are wingless, and this, of course, is another reason why the winged male should be well equipped for seeking and finding his partner.

Again, when the moths "assemble" in the open it does not necessarily follow that the first male to arrive is the one selected. First one and then another approaches the apparently motionless female, brushing her with his wings until finally, for some, to us, mysterious and unaccountable reason, one is selected as her mate. Almost at once the rejected males begin to disperse, offering no resistance to the successful suitor. How the choice is indicated and announced is beyond human comprehension. As a possible solution of this problem, I would suggest that the subtle influence of smell, or whatever it may be, exerted by the female to attract her mate is no longer emitted by her when she has made her choice, and that the males immediately detect this and abide by the decision.

The odours of flowers are intimately connected with the sense of smell in insects, and these are very numerous, some five or six hundred having been distinguished. Two distinct kinds of scent may even be liberated simultaneously by the same flower, one or the other predominating, perhaps, at different times during the day. Flowers that depend for pollination upon dusk-loving insects are generally white or pale-coloured, and often open their petals and become most fragrant as night approaches. If unduly small, they make themselves more conspicuous by aggregating together. The honeysuckle, or woodbine, shows these characteristics, and depends for pollination upon hawk-moths and similar nocturnal insects. It therefore begins to open the blooms that need pollination, and to emit its fragrance in real earnest, about 6 p.m. Then, too, these flowers turn down into positions which will readily permit

the hawk-moth to reach the nectar, which is contained within the tube of each flower. The moth does not alight upon the flower, but remains poised before it by the rapid vibrations of its wings, while it sips the sweet liquid by means of its long tongue or proboscis.

Other examples of the keen sense of smell possessed by insects may be instanced in the blow-fly and burying beetles. Indeed, the ancient philosophers believed that maggots and flies were generated by putrefying substances. Redi, however, was dissatisfied with certain experiments he made to prove this, and he therefore carefully covered meat with paper and silk. The flies were nevertheless attracted by the smell of the covered meat, and, though unable to reach it, many of them deposited their eggs upon the silk and paper, these eggs eventually hatching into maggots; the meat, however, remained free from maggots while it was covered. Thus Redi was able to show that no flies could appear except from eggs deposited by the parent insect, the latter being guided to suitable situations by its keen sense of smell.

Likewise with the burying, or sexton, beetles. These insects hunt in pairs by scent, and rarely can a dead animal be met with under which one or more pairs may not be found. The male insect pushes away the soil in furrows by means of its broad head, burying the bird or other animal together with his bride; the latter then depositing her eggs within the carcase.

Lord Avebury (then Sir John Lubbock) has shown, too, that ants possess a highly developed sense of smell; while in bees it is not so acute.

As previously stated, the organs of smell in most insects probably reside in the antennæ—very complicated organs, which may be the seat of many senses, of some of which we may not be cognizant; as we have previously seen, they may serve as organs of touch as well as smell, and, as I hope to show now, they may also act as ears.

Hearing

To prove that an insect possesses the sense of hearing presents many difficulties. However, perhaps one of the most plausible arguments is that, if insects produce sounds which have relation to their habits, they will possess organs of hearing to receive those sounds. Then it is quite reasonable to ask, where are the ears of insects?

Naturally we turn to the head in our search for these organs. Here, though, we can trace nothing analogous to our ordinary idea of ears. A detailed examination of the anatomy of insects has led many naturalists to the conclusion that the organs of hearing in these animals need not necessarily be in the head. There is, indeed, conclusive evidence that some species of insects have well-formed ears in quite other parts of their bodies and limbs—of which more anon.

As I have previously hinted, many reliable observations have been made which tend to show that the antennæ serve as the organs of hearing, in addition to possessing olfactory and tactile functions. Seeing, too, how complex is the structure of the antennæ of many insects, there is no reason why the three senses just referred to should not be carried on by them. Hicks has recorded that on one of the antennæ of a blow-fly there are no less than 17,000 small perforations, besides larger orifices all connected with curious sacs, varying in form, size, and number, and all of which are probably associated with sense functions. The complexity in the structure of the antennæ increases according to the importance of these organs in relation to the habits of the species. The bee, for example, possesses about 20,000 pits, and 200 cones on each antennæ.

Insects being endowed with such complex sense organs, it is not surprising that evidence has been adduced that these animals make, and can hear, sounds quite beyond the range of man's sense of hearing. Indeed, experiments have shown that, while ordinary noises produced no effect

upon ants, bees, and wasps, imitations of their own sound productions, made with suitable implements, both excited and (by reason of their unnatural and inaccurate imitation) alarmed them. From the fact, too, that the sounds we hear produced by many insects are very shrill, it is probable that the hearing powers of such insects may commence near where our own terminate; also that they may possess the faculty of hearing much sharper sounds than lie within the compass of our sense of hearing. Authentic records have been made of people who, although not suffering from deafness in the ordinary way, were yet unable to hear the call of a hedge-cricket, or even the chirping of a house-sparrow. A very familiar example of this lack of acute hearing is illustrated by the shrill squeaking of bats as they fly about at dusk, many people being quite insensible to this sound.

Of the sounds produced by insects many are love-songs. The call of the male cricket, for example, is said to attract the female insect towards him. The sound is not produced by the mouth, as one might at first suppose, for no insect possesses a true voice, but is a mechanical noise produced by rubbing a notched or file-like nervure of the left horny wing-cover against another bar on the right wing-cover. It is significant to note that in some grasshoppers the females are also provided with stridulating organs, and that these probably make sounds audible to their mates, though not to human ears.

With insects so provided with musical instruments, we might reasonably expect to find fairly well-developed ears; and we are not disappointed. The curious fact, though, is the position of these ears, which are situated in the fore legs, just below the knee (Fig. 166). These organs consist of an opening leading to a membrane extended over an air space, constituting a kind of drum, and connected in turn with sensory cells. To what kind of sounds these curiously placed ears are sensitive we cannot say with any certainty, but their acoustic functions have been investigated and placed beyond doubt. Probably they are adapted to the precise location from which sounds proceed, for when a sound is heard the legs are turned about

in different directions as if to meet the vibrations. In grasshoppers a different arrangement occurs, and somewhat similar ears are found, one at each side on the first ring of the abdomen. Furthermore, it has been shown that crickets probably also hear with their antennæ, and this leads to the conclusion arrived at in other directions—namely, that the sense of hearing is not necessarily confined to one part of the body. Many insects have no apparent ears, although

Fig. 166.—One of the fore legs of the mole cricket, showing one of its ears.

there is considerable evidence to show that they possess the sense of hearing, and probably, in such cases, it is located within the complex organization of the sensitive antennæ.

The male gnat has beautifully feathered antennæ (Fig. 167), and, Mayer, who made a series of experiments with this insect, says, "The hairs on the antennæ of the male gnat vibrate in unison with the notes of a tuning-fork within the range of sounds emitted by the female. The longer hairs vibrate

sympathetically with the graver notes, and the shorter with the higher ones." So the humming sound of the female gnat, or mosquito, is, like that of the cricket, probably a love-song.

FIG. 167.—One of the beautiful antennæ of the male gnat, or mosquito, by means of which it hears the humming sound made by the female insect.

However, in this case it is the female that produces the music, thus calling her mate towards her.

Finally, then, while the organs of hearing are probably situated in the antennæ or "feelers" of most insects, yet, as we

have here seen, others may have specially organized ears; while even the latter may also possess further organs of hearing in their antennæ. Also, there is no reason to assume that the organs of hearing in insects must be confined to the head or any other part of their anatomy simply because our own are so definitely placed, for, as previously stated, the "ears" of insects may often have to deal with sounds which we do not know exist, and therefore may consist of structures which bear no analogy to man's organs of hearing.

Sight

Of the actual power of vision amongst insects we know but very little. It is, doubtless, the most complex of the five familiar senses to investigate. In the first place we find that most insects possess two kinds of eyes: (1) the large prominent compound eyes situated one on each side of the head; (2) the camera eyes, or ocelli, which are smaller, usually three in number, and are arranged in a triangle on the top of the head between the compunod eyes.

The ocelli probably correspond in function to our own eyes, the refracting surface, or lens, throwing an image on the retina, or sensitive lining layer of visual cells; just as the lens in a camera throws an image on the sensitive plate. In the eye, however, the process goes further, for the retina is connected with delicate branches of the optic nerve, which conveys the picture to the brain. But, although the ocelli are analogous to our own eyes, yet in details of structure they are much simpler. Indeed, it is highly probable that the image they present is very imperfect—at all events as regards distant objects. Some naturalists have gone so far as to regard these ocelli, or simple eyes, as quite rudimentary organs of little or no service to the insect. This, though, is perhaps going too far, for spiders possess ocelli only, and there is good reason to believe that these animals can see, although evidence points to their possessing a very short sight. This, too, agrees with the decisions arrived at with regard to these

same organs in insects, namely, that the ocelli are used only for near vision. Furthermore, it is probable that they also serve to see with at night, or in dark places; Lord Avebury has pointed out that "the night-flying moths all possess ocelli, while they are entirely absent in butterflies." Other observers, too, have come to the same conclusion regarding the eight ocelli of spiders, some being supposed to be for use during daylight, and others at night. Therefore, the sum-total of our

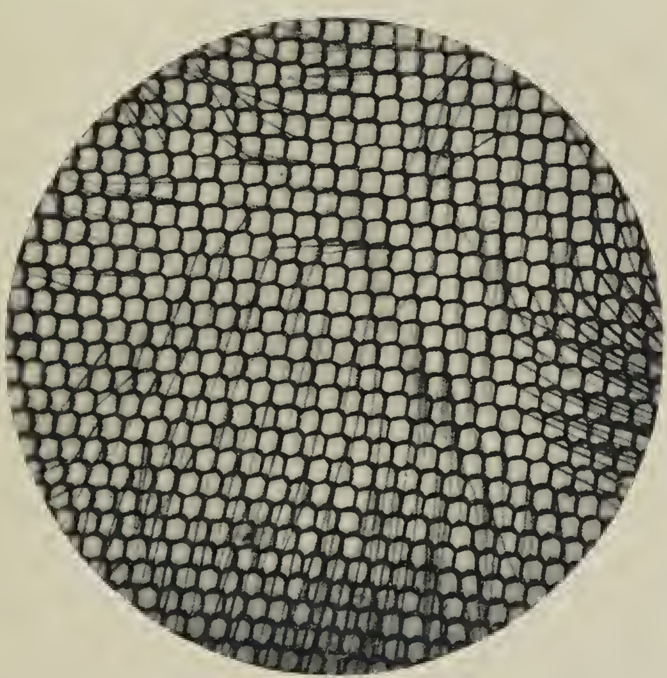

FIG. 168.—A few of the 4000 facets, or lenses, in the compound eye of a house-fly.

present knowledge of the function of these organs may be summed up by saying that they serve for near vision, and are probably useful in the dark.

The compound eyes are characteristic of such animals as lobsters and crabs as well as insects. These remarkable structures vary in detail very considerably in the different species of insects. When examined with a magnifying lens each of these eyes is found to be covered with a horny

coating, divided up into an immense number of minute areas, these being square, hexagonal, or polygonal in form. The remarkable feature, though, is that each of these areas, or facets, as they are termed, acts as a lens, and produces a perfect image.

Now, more than a century ago, Leeuwenhoek calculated that in the compound eye of the house-fly (Fig. 168) there are about 4000 of these facets, or lenses. This is by no means a large number, either, for the same authority estimated that the

FIG. 169.—A few of the 25,000 facets composing the eye of a beetle, showing an image of the writer's pen in each.

eye of the gad-fly possessed 7000; goat moth, 11,000; death's-head moth, 12,000; swallow-tail butterfly, 17,000; dragon-fly, 20,000; a small beetle, 25,000. As I have previously remarked, each of these facets presents an image; and if we examine beneath a microscope the cornea, or faceted area of the eye of an insect, and view through it the image of a candle-flame, the end of a writing-pen (Fig. 169), or other suitable object, reflected into the field of vision by a small mirror, we instantly get presented a multitude of minute images, each facet, or lens, of the cornea forming a distinct picture. Then the

question arises, does the beetle (let us say) see one image of the object it views, or 25,000?

Apparently the microscope seems to decide the point. However, it really decides nothing, because, taking our own two eyes as example, each of these produces an image, yet we get only one picture conveyed to the brain. Similarly with the multitude of images that the eye of a fly or beetle takes up, these may finally produce but one picture.

The most plausible explanation of how insects see with this class of eye was suggested by Johannes Müller in his theory of "mosaic vision." He contended that each of the numerous visual pyramids beneath the facets (which are optically separated by a dark-coloured pigment) receives only those rays of light which pass in the direction of its long axis, or are reflected from its sides. In this way each pyramid would only admit a small amount of light from the field of vision, with the result that a large number of light points would be produced. By the co-operation of these a mosaic picture is built up, which probably presents a view more or less distinct, according to the arrangement of the numerous pyramids that compose the eye mass, together with the greater or lesser complexity of their adjoining sensory parts, these latter varying greatly in different insects.

There is no striking evidence to show that insects possess very keen sight; in fact, experiments seem rather to favour the view that their vision is weak and has but a short range, and that they can distinguish form but badly. It is true that when we watch the movements of such insects as blow-flies, or dragon-flies, they do appear to possess an acute sense of sight; however, I have previously pointed out that it does not do to judge by appearances. They may not be guided in their movements by the sense of sight at all, but by other senses of which we have no knowledge. We might contrast with these apparently watchful movements of the blow-fly and the dragon-fly those of a moth, or cockchaffer-beetle, when it is seen dashing itself recklessly against the glass of a street-lamp, or the globe of an electric arc-light. Can these insects see when

they are so engaged? Again, what sense is influenced to cause them to injure themselves (as they frequently do) by such rash and heedless conduct? Indeed, the whole subject is full of fascinating interest; and, as a final word, I cannot do better, perhaps, than quote from Lord Avebury's interesting work "The Senses of Animals." He writes: "We have five senses, and sometimes fancy that no others are possible. But it is obvious that we cannot measure the infinite by our own narrow limitations . . . we find in animals complex organs of sense, richly supplied with nerves, but the function of which we are as yet powerless to explain. . . . The familiar world which surrounds us may be a totally different place to other animals. To them it may be full of music which we cannot hear, of colour which we cannot see, of sensations which we cannot conceive."

CHAPTER XV

The Life Story of the Goat Moth: a Moth that fells Great Trees

PROBABLY every one has, during his country rambles, observed from time to time a tree such as that depicted in illustration Fig. 170. The photograph shows a wrecked ash tree—a tree, evidently, that was once healthy and flourishing, otherwise it could not have attained such proportions. What, then, brought it to its present state?

From a superficial glance we might imagine that lightning had been the first factor in its destruction, and that afterwards wet, frosts, gales, and other external elements had played their part. If, however, we approach the tree more closely, we shall discover conspicuous traces of the work of a much more insidious foe than any of these.

On looking into the heart of the tree trunk, where it is seen to be broken open, we observe that it is riddled with holes, many of them wide enough to admit one's finger, and by pulling away some of this riddled wood (which crumbles as we touch it), we find that these holes are the openings to tunnels or burrows; in fact, we soon discover that the once solid trunk has become a dry, powdery mass, honeycombed with these tube-like passages in every direction (Fig. 171). Also, we cannot fail to note that the tree possesses a powerful and rank odour; and, if we have freely handled the crumbling wood, our hands, and it may be our clothes, will have acquired this same smell; and so powerful and persistent is it that its presence may be detected for several days afterwards.

What light can these observations throw upon the destructive enemy of this once robust and healthy ash tree?

FIG. 170.—A victim of the goat-moth.

Let us go back a stage, to a time only seven years before, when this ash tree was a fine and beautiful example of its

kind, spreading wide its branches clothed with their innumerable

FIG. 171.—A closer view of a portion of the same tree, showing how the wood is riddled with holes.

compound leaves, and decorating with shifting light and shadow the neighbouring roadside and tiny streamlet. In truth,

all was going well with our tree until a particular night in July, a night when there came swiftly flying along this leafy lane a moth—one of the largest of British moths, having grey wings traversed with a network of dark brownish lines.

As the moth neared the ash tree, she (for it was a female

Fig. 172.—The female goat-moth (natural size), searching the deepest crevices of the bark in order to deposit her eggs.

insect) fluttered towards the earth, and a moment later she had alighted upon the ground near the foot of the tree. Then she moved rapidly towards its trunk, and eventually came to rest upon the bark just above the soil. At all events she apparently rested, but in truth she was never more busy in her life. By means of a sharp-pointed ovipositor situated at the end of the

abdomen she was carefully searching the deepest niches and crevices of the bark (Fig. 172). Then she moved to another part of the bark and carried on very similar movements there. For an hour or more she was occupied with this work, and then she took to her wings again, to visit, it may be, another tree, which she would treat in a like manner.

That was the beginning of the tree's destruction, for the

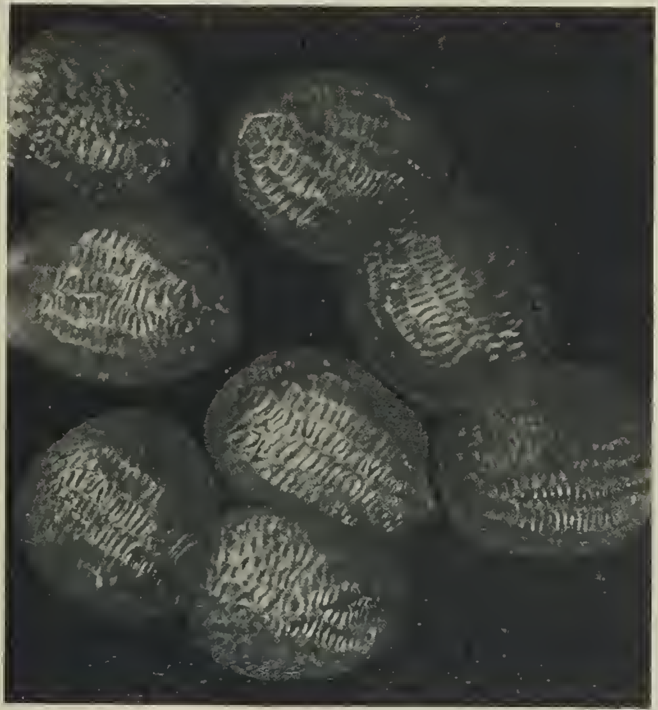

FIG. 173.—The eggs seen through a magnifier.

cracks of the bark, into which the moth had penetrated with her ovipositor, were now crowded with little rounded greyish-coloured bodies with brown markings. Each of these tiny objects was but very little larger than a pin's head, and curiously grooved about its surface. Some of them, as seen magnified by the writer's pocket lens, are shown in Fig. 173.

I need hardly add that these curious little objects were the

eggs of the moth, which, with true parental instinct, the mother moth had carefully placed in the situation best adapted to the needs of her offspring when hatched.

The tree went on growing and building up new material for future use. In the following spring its innumerable buds responded to the influence of the warm sun, and from them came many new branches, bearing in their turn leaves and leaflets. By the following autumn the ash had produced large quantities of its curious winged fruits (familiarly called "keys"), that, on windy days, merrily whirled surprising distances into the neighbouring fields as they fell from the branches. Superficially, everything with our tree was prospering.

About this time, however, an entomologist came along the lane, and as he neared the ash he halted and sniffed, and then he muttered "Goats!" Forthwith he began to inspect the various trees in the vicinity, and as he approached one of them he knew at once that he had found the object of his search, for he heard the buzzing of a small host of bluebottle flies as they left a particular tree and took to their wings. The flies, like the entomologist, had been attracted towards the ash by the strong smell. Wasps, hornets, and some of our most handsome butterflies, are likewise attracted by this smell, although to man it is repugnant. Indeed, the odour is said to resemble that from the male goat (hence the name "goat-moth"); by others it has been compared with that of strong acetic acid, the latter perhaps being the more appropriate comparison.

The entomologist carefully removed a portion of the bark about a foot above the place where the moth had deposited her eggs during the previous summer. The bark came freely away, and the outside of the young wood was seen to be perforated with many holes, from most of which the juices of the tree were oozing out. No one knew better than the entomologist that the fate of that tree was sealed. He, however, had no thought for the tree itself; instead, he anticipated getting some choice specimens of goat-moths for his cabinet, and so he carefully made some entries in his note-book

to remind him when to visit the tree again, and then the quarry was left to thrive.

It was not until the spring of the next year that he returned

FIG. 174.—Larva of the goat-moth (natural size) at work in the trunk of the tree.

to the tree, about the end of May. Again he removed some of the bark and loose wood, which had now become soft. The perforations were now large and conspicuous, and as he broke away the wood it became more and more obvious that

these openings led to irregular ascending galleries, many of which extended upwards to four or five feet within the interior of the trunk. It did not take the entomologist long to expose the cause of these ramifications.

Fig. 175.—When interfered with they had a way of turning angrily round as if to bite.

In some of the harder parts of the wood were large uninviting-looking larvæ, many of them between three and four inches in length and as thick as a man's finger, flesh-coloured at the sides, and deep red above (Fig. 174). Also, they had

wedge-shaped heads, well adapted for penetrating the solid wood on which they were feeding; and when interfered with, they had a way of turning angrily round with open jaws as if to bite (Fig. 175). As a matter of fact, however, they are quite harmless, apart from their power to secrete the liquid which produces the rank odour previously referred to, and which, I may remark, requires more than soap and water for its removal from hands and clothes.

Here, then, was the harvest of those tiny eggs placed upon the tree by the mother moth about a year and ten months before. After a little while from each egg came a baby caterpillar, which penetrated the bark and fed for a time between it and the young wood. In the following spring, however, each of these larvæ commenced its work of running long galleries into the solid wood of the tree; and as more than a hundred of these larvæ had been engaged upon the work for nearly two years, it is not surprising that some of the topmost branches of the tree had begun to lose vigour—an effect more easily realized when we grasp the fact that each of these larvæ increases in the course of its development to 72,000 times its weight when hatched. If an average child were to increase its weight at this rate from its birth to manhood, it would then turn the scales at about 225 tons.

Some of the larvæ had by no means reached their full size, and these would feed and burrow into the tree for yet another year. However, many of them had thrived so well at the expense of the tree's substance during the two years, or thereabouts, of their caterpillar life that they were almost ready for the next stage in their development. One, indeed, had already formed its cocoon of "sawdust" and broken bits of wood lightly spun together, and had snugly ensconced itself within (Fig. 176).

The caterpillar would rest for a day or so as shown in the illustration, and then it would moult its skin. When the skin had slipped off, the caterpillar would be seen to have changed to a large pupa or chrysalis of a reddish-brown colour.

A month later our friend the entomologist would have to keep a sharp look-out for his specimens, for the pupa then would push its way through its cocoon into the burrow and later towards the surface of the decaying and broken bark, near which the cocoon is generally placed. The pupa is

FIG. 176.—A larva in its cocoon of wood-dust, in readiness to become a chrysalis.

perfectly adapted for these movements, being wedge-shaped in front and provided with rows of short spines arranged around each segment of its body to prevent it slipping backwards.

On reaching the surface of the tree, the pupa would protrude some two-thirds of its length, and then its skin would

break, and so the winged moth become free (Fig. 177). The empty pupa-case is left projecting from the hole, numbers of which, in the proper season, may sometimes be seen about the surface of a badly infested tree. Occasionally, but less often, one of these larvæ pupates in the ground, forming its cocoon of particles of soil; an example of this kind is shown in Fig. 178, where the chrysalis-shell is seen protruding from the cocoon just as it was left after the emergence of the moth.

FIG. 177.—A female goat moth, showing the sharp instrument used for penetrating the crevices of the bark when egg-depositing.

Should the entomologist arrive upon the scene at any time within an hour of the moth's emergence from the pupa, he will be sure of his quarry, for it will then be resting upon the bark, unfolding and drying its wings ready for flight. By its capture he will render an untold service to the owners of neighbouring trees, for, as I have here shown, one moth may ruin a valuable tree—and then, should all the offspring of that moth reach maturity, we may well ask how many trees will they in their turn destroy.

Fortunately Nature has appointed a few vigilant detectives to keep in check this destructive insect, the most useful of these being an ichneumon fly that deposits its eggs in the bodies of these larvæ, the ultimate result of this action being that the chrysalides of the goat-moth produce ichneumon flies instead of their own species, these flies having developed parasitically at the expense of their caterpillar host. Then there is

FIG. 178.—A cocoon composed of particles of soil. The chrysalis is seen protruding from the cocoon just after the emergence of the moth.

the green woodpecker, which cuts holes in the tree by means of its powerful beak to extract these fleshy larvæ. And as the market value of a good specimen of the goat-moth is eightpence or ninepence, the entomologist may be counted as another persistent enemy.

Even with these diligent foes all in harness, during some seasons this destructive insect becomes very abundant, and then standing timber has to suffer, the most healthy trees being

the ones attacked. Ash, poplar, willow, walnut, beech, lime, birch, sycamore, and many other trees in their turn become victims; but it is when oak trees are attacked that the most serious loss results.

The moth is fairly abundant throughout Europe and Western Asia, and it is also found in North Africa. In the British Isles this insect is so destructive that the Board of Agriculture have issued a leaflet descriptive of it and describing preventive and remedial measures; this is supplied gratis to applicants.

FIG. 179.—The completed work of the goat moth.

However, the only method of dealing with badly infested trees seems to be that of felling and splitting them to destroy the caterpillars lurking within. While this means sacrificing the tree, yet it is the best preventive against other trees being similarly attacked. Even should the enemy be ejected, the rain eventually penetrates the burrows of the larvæ and rots the wood, and then wind and gales do the rest, until the once great tree becomes a thing of the past (Fig. 179).

CHAPTER XVI

The Life Story of the Swallow-tail Butterfly and its Parasite

THE swallow-tail is the largest of British butterflies, specimens measuring from four to five inches across their expanded wings; and, besides, it is perhaps the most handsome insect of its kind that Britain possesses, and this even though it has to compete both in size and display of colour with the renowned purple emperor butterfly. In size the swallow-tail is generally first, the largest specimens of the purple emperor being about on a par with the smallest swallow-tails; as regards colour, the sheeny purples, browns, and whites of the emperor are so different to the decided and conspicuous yellows, blues, blacks, and reds of the swallow-tail that the insects hardly bear comparison. Therefore, we can at least say that the swallow-tail is the largest British butterfly, and, on account of the peculiar array of its extraordinary colours, we might also add, the most striking in appearance.

This rare and handsome insect, however, has to pay dearly for its honourable position in England. On the Continent it is common enough, and some sixty or seventy years ago it appears to have been fairly abundant in southern England, but as drainage and cultivation have extended, it seems to have disappeared more or less completely from all districts excepting some of the undrained fens in a few eastern counties.

Drainage and cultivation (which mean the destruction of the food plants of the larvæ) are not the only troubles that the swallow-tail has to contend with. Indeed, its life in this

country is full of trials, and this accounts for its scarcity, while the mere fact of its comparative rarity excites to action another formidable enemy in the entomologist, or insect collector. Of course, no collection of butterflies would be complete without a pair of these choice specimens, and although most of the specimens seen in cabinets are reared in captivity, yet, unfortunately, many collectors exhibit an altogether unnecessary desire to take scarce insects on the wing from their native haunts. Consequently, if a brood of such insects happen to crop up unexpectedly in a new district, probably some dealer in entomological specimens promptly discovers their advent, and is soon following in their wake with nets and other paraphernalia ; then, of course, that brood of insects does not benefit its race very much. Even worse than the dealer is the enthusiastic amateur who discovers such a brood. Excited by his find and reckless in his pursuit, he captures and kills every insect that comes his way, until he often leaves them more or less exterminated. The tactful dealer, in his own interests, will release damaged and imperfect specimens in the hope that they will furnish a brood for the future, but the amateur is prone to be much less considerate.

The amateur collector should always content himself with one or two specimens of any rare insect that he may find, even though it may be a self-denial to do so, then he is justly entitled to the designation of entomologist, or student of insects, in the strict meaning of the word ; but so long as he greedily destroys insects wholesale, he is not an entomologist, but rather an enemy of the entomologist, and is comparable only to the ruthless individual that wantonly pulls up ferns, violets, primroses, orchids, etc., by the roots from the country lanes on the outskirts of towns.

Surely, then, you would think that a species of insects so poorly represented has enemies enough to contend with in man and his destructive work in draining the lands which once were the insects' preserves, and that Nature would try to hold out a protecting hand to them. But no, the reverse is true. Man and his work may be described as artificial or non-natural

enemies of these insects; but the butterfly has far worse natural foes to contend with. And of one of these foes I propose to give you some details, but first I will consider a few points in the development of the butterfly itself.

In Fig. 180 are shown two swallow-tail infants, feeding on

FIG. 180.—Larvæ of the swallow-tail butterfly.

one of the umbelliferous plants on which they are usually found, for, of course, before the butterfly there must be a caterpillar. The larvæ, too, are very striking in appearance, the colour of the body being pale green conspicuously marked with black bands studded with orange spots. The first brood of these handsome caterpillars usually hatch from the eggs and

commence to feed in early June. The first meal of the larva consists of its empty eggshell, after which it begins to take its green food. It soon grows too big for its skin, and consequently moults it, and then, before again feeding on green food, it carefully eats up its old skin. In this manner it moults its skin several times, and with each new skin, as it gets older, its colours become more conspicuous and striking, until, about the end of July, the stage shown in Fig. 180 is reached, where

FIG. 181.—How the swallow-tail butterfly spends the winter—the chrysalis.

the larvæ are seen full-fed and ready for the next phase of their development.

The larva then attaches itself by silken threads at its tail end to the stem, also by a silken girdle just above the centre of its body. Then it moults its last caterpillar skin and becomes a pupa or chrysalis, as shown in Fig. 181.

The chrysalis at first is green, but later it changes to a yellow brown; in fact, it discolours contemporaneously with the stems on which it rests as they dry, and so probably

gains a measure of protection by this mimicry of its surroundings. Sometimes, if the weather is very favourable, some of the butterflies appear in August; and that generally means another brood of caterpillars in early September, and which become butterflies the following spring. More often, though, the August butterflies do not appear, and the chrysalides remain quiescent throughout the autumn and winter months. Frail though they are, and subjected to all the

FIG. 182.—The butterfly.

vicissitudes of the wintry weather, and doubtless frozen and thawed many times, yet, in spite of all this, in the early spring there *may come* from the chrysalis a delicate and fragile butterfly, which quickly unfolds its wings and reveals their glories to the sunlight (Fig. 182). I say "may come" advisedly, because sometimes the butterfly collector who in the autumn has diligently gathered the chrysalides from their reedy haunts, gets a surprise that is not at all agreeable to him.

In Fig. 181 a chrysalis of the swallow-tail butterfly is shown as it appears in the autumn, but it would be a rash entomologist who would definitely state that a butterfly would come from it in the spring, even allowing that no accidents or mishaps should occur during the period that the chrysalis is maturing. For from that chrysalis there may

FIG. 183.—Evidently something was wrong! The chrysalis was being opened from the side instead of the back.

come an insect that has no relation with butterflies whatsoever; indeed, an insect of a different class entirely, and one more nearly related to the bees and wasps. Surely, though, you will say, a butterfly's chrysalis must reproduce its species, just as an apple tree must reproduce apples. And, in truth, so it should, but sometimes the enemy creeps in midway.

In Fig. 183 is shown a chrysalis that was arranged for the purpose of photographing the butterfly when it emerged, but

the emergence, when it came to pass, turned out very different to what had been anticipated.

Early one morning, much later in the season than when the butterfly should have appeared, a tiny hole became apparent on one side of the chrysalis, which an hour or two later had increased in size. When I looked into the opening thus made, a pair of rather startling insect's eyes could be seen

FIG. 184.—The enemy appears and—

peering through. The photograph shows these plainly enough, but probably in reproduction they may not be so visible. Also, it was obvious that the insect within, whatever it was, possessed sharp and strong mandibles, and with these it was slowly biting its way through the hardened chrysalis shell.

The insect worked diligently and persistently for several hours, occasionally pushing through a leg to test if the hole was large enough for its egress. After working for nearly five

hours it got its head and one of its fore legs through in a sideways position, and immediately the other fore leg followed. It then gripped the chrysalis below with these two legs and so pulled itself out, its wings thereupon appearing (Fig. 184). Not a moment was lost; the battle was won, and the insect was free. It quickly dragged itself out and fluttered its wings, its feelers, body, and limbs, at the same time twitching with

FIG. 185.—rapidly frees itself from the chrysalis of its late host.

wonderful activity for an insect only just emerged from chrysalis (Fig. 185). A moment later it was travelling up the stem (Fig. 186), still exhibiting the same extraordinary activity. A few minutes later it had trimmed its wings and taken its flight.

What did it all mean? How had our chrysalis produced so strange an offspring? Where has that curious fly gone, and what will it do? These are questions that naturally follow.

And for the benefit of the young entomologist that may meet with such an occurrence in the development of this or other species of butterflies (for similar instances may occur with almost all species), I will endeavour to follow that mysterious fly a little further, and so learn how it gained access to that chrysalis.

Such insects are known as ichneumon-flies, and they offer a

FIG. 186. The ichneumon-fly emerged and ready to depart upon its destructive work amongst the caterpillars.

striking instance of how Nature keeps one organism in check by means of another. Their duty in the natural world is to attack the numerous caterpillars that are so destructive to vegetation, although the larvæ of some other insects, and even spiders, are sometimes also attacked. There are over six thousand species of these insects known to science, and twelve hundred of these are British. The common white cabbage-butterfly, whose larvæ are so destructive to cabbage plants, has

two species of ichneumons which prey upon its caterpillars, and two others at least which attack it while in the chrysalis stage, while still another is known to pierce this butterfly's tiny eggs and deposit within them its own still smaller eggs. They are particularly active insects, always twitching their feelers and moving rapidly amongst the foliage while seeking for caterpillars. I need hardly add, too, that they are amongst man's best friends in the garden.

Now, our fly having emerged, away she flew, and, doubtless, in due course she would meet her mate. After the marriage, she would have to give attention to family matters, which generally in the insect world means only the placing of the eggs in a suitable position for the development of the offspring when it appears. So one morning off she starts to select suitable sites for this purpose. She wings her way by sunny fields and lanes, but they have no attraction for her. At last she reaches the marshlands, and there she at once becomes interested.

Amongst the marsh vegetation she moves rapidly, running up and down the stems and across the leaves, apparently quivering with excitement the whole time. Presently she runs against a nearly full-grown caterpillar—a swallow-tail butterfly caterpillar—and then it is possible that she jumps for joy, for she has found that for which she was seeking. This is her favourite caterpillar, the nurse she prefers above all others for rearing her progeny. She therefore boldly attacks it, and, alighting upon its body, thrusts deep into it her ovipositor, and leaves there an egg. When the ovipositor is withdrawn, the fate of that caterpillar is sealed; it will never become a butterfly, for its substance is henceforth destined to nourish a parasite—the grub or larva of an ichneumon-fly.

While the ichneumon wanders further in search of other victims (which may be perhaps sometimes newly formed chrysalides as well as caterpillars), the caterpillar goes on feeding as if nothing had happened. Its appetite increases greatly as time goes on, for it then has to nourish a hungry parasite within that makes great demands upon its blood or sustaining

fluids. In due course, the time arrives when the caterpillar should become a chrysalis, so it diligently struggles to achieve that end, and it usually succeeds, but there its history terminates.

The hungry parasitic grub within has by that time developed

Fig. 187.—Another ichneumon-fly and its empty butterfly chrysalis.

somewhat considerably, and ravenously consumes not only the nourishing fluids of its host, but all its vital parts as well, eating out the whole until nothing is left but the shell of the chrysalis, which then drys and hardens and so serves as a chrysalis for the parasite.

So in this chrysalis of its late host it lies by throughout the winter and spring, and then, in the early summer, when swallow-tail caterpillars are moving about, it wakes up and bites its way out, so that it may go in search of them (Fig. 187).

Having now returned to our starting-point, I need only add that it seems strange that Nature should be so hard on an insect that is so rare and so sorely persecuted. But we have to remember the fact that its scarcity of numbers in this country is but its misfortune. If the natural conditions were favourable to its development, it is possible that it would be as common, and as great a pest, as the familiar white cabbage-butterfly, which needs several species of ichneumons to keep it in check. However, its parasite finds the conditions of this country favourable to its own development, and as it, doubtless, attacks other larvæ besides that of the swallow-tail, it prospers.

CHAPTER XVII

The Life Story of the most Familiar of English Butterflies

THE exact number of butterfly species that inhabit the British Isles is a very controversial point, but even the largest estimate does not exceed seventy. Even of these seventy, several species are very rare, and but seldom seen. On the other hand, some are very abundant, and, more or less, may always be seen in due season.

Everybody, for example, knows the common white cabbage-butterfly. Its yellowish white wings with black tips (and in the case of the female insect with black spots also) may be seen fluttering along over gardens, fields, and streets almost everywhere in the British Isles during the summer months.

When visiting town one day last summer, I saw, shortly after noon, one of these insects zigzagging its way above the crowded thoroughfare of the Strand, dodging omnibuses, drivers' whips, and other things that obstructed its path, in a manner that seemed to imply that it was quite enjoying the fun of the thing. Probably, though, this insect's visit to London had been *viâ* Covent Garden Market, whither it had most likely been carried from its country home (not as a butterfly, but as something altogether different in form, and of which more anon) along with a basket of cabbages; for, as we shall see later, this butterfly has a great affinity for plants of the cabbage family.

My readers may have noticed, too, that these insects apparently vary somewhat in size. When small examples are

seen, however, it does not follow that these are young butterflies, for when an insect reaches the winged state it has completed its development so far as growth is concerned, and this is true of butterfly, house-fly, beetle, or moth. The smaller examples in colour and markings very much resemble the larger forms, but, nevertheless, are a distinct species. While the former measure only from one and three-quarters to two and a quarter inches across their expanded wings, the latter

FIG. 188.—The butterfly travels quickly along, its limp and flimsy wings draggling over its body as it goes, until it reaches—

are rarely less than two and a half inches and they may reach two and three-quarters. In the earlier stages of their development the two species show much greater differences, and are then more easily distinguished.

Thus we have the small white cabbage-butterfly (*Pieris Rapæ*) and the large (*Pieris Brassicæ*). There is little doubt but that these two species represent the commonest and most familiar examples of British butterflies; but which of the two

is the more abundant is difficult to determine; for, while one species may be most prolific during one year or part of that year, the other may be just as plentiful the following year, or even at a later season of the same year; for two or three broods of these insects may appear in one year if the weather be favourable. The two insects have many characteristics in common; but it is the life history of the larger species that I have detailed and illustrated here.

FIG. 189.—a branch or leaf to which it can suspend itself, while clinging by its feet. In this attitude its crumpled wings fall from their folds, and soon become dry and rigid.

The large cabbage-butterfly makes its appearance in May or early June, and, after we have seen one butterfly on the wing, they daily become more and more abundant. Not infrequently, about this time, we may see one travelling along the garden path with its wings curled up in a curious fashion, creating the impression that it is crippled. It is interesting to watch one of these apparently crippled insects. First, though, let us lift the

insect from the ground and place it on a branch of a tree, where we may better watch what happens to it (Fig. 188).

The butterfly travels quickly along the branch or leaves, its limp and flimsy wings draggling over its body as it goes. Soon, however, it finds the spot that it is seeking for—the end of a branch or leaf to which it can suspend itself while clinging by its feet. In this attitude it comes to rest, its wings then falling out of their crumpled folds and hanging down (Fig. 189).

FIG. 190.—The butterfly eventually climbs higher up the branches towards the bright sunlight, and there suns itself for a little while.

There the insect remains for at least an hour; meanwhile its soft, limp wings undergo a considerable change. As they hang exposed to the atmosphere they slowly dry and become rigid, and, in this way, the draggled aspect of the insect gradually disappears. In fact, from its "crippled" appearance, it is slowly transformed into a trim and lovely butterfly, with creamy white wings tinged with yellow and back tips

and spots—the latter feature denoting that it is a female of its species.

Soon the butterfly itself discovers what has happened, and its antennæ or "feelers" begin to twitch and move rapidly. Then its wings are suddenly fluttered (for now that they are rigid the insect has them under muscular control), and the insect moves higher up the leaf or branch towards the bright

Fig. 191.—At last, tempted by the bright sunlight, it gives itself a good push off from the branch, and is suddenly zigzagging and see-sawing its way across our neighbour's garden.

sunlight at the surface (Fig. 190). It rests there and suns itself for a little while, and then, tempted by the bright sunlight, gives itself a good push off from the branch (Fig. 191), and is suddenly zigzagging and see-sawing its way across our neighbour's garden.

Not so bad for a "cripple," we think, as we watch its movements; then the butterfly suddenly swerves from the route on which she was travelling, being headed off her path

by another of her species, which apparently espied her from some flower below on which it was occupied. The two insects then fly towards us, circling round and about each other as they come, and as they pass we observe that the companion insect *has no spots upon its wings*.

Yes, there is no doubt about it—this has been a love-match. For some time the insects remain in view while they carry on their merry courtship, every now and again dropping down to feed upon the refreshing nectar of flowers whose coloured petals attract their eye from above; and then, having quenched their thirst, rising again fresher than ever to renew their love-making.

After the marriage there will be a number of curious little eggs (Fig. 192) deposited in clusters, and most probably on somebody's spring cabbage plants. It would, of course, be most unfortunate if that somebody happened to be the individual who assisted Mrs. Butterfly when she found herself, with limp and wet wings, struggling to find a suitable branch on which to dry them before they became damaged by contact with the rough stones and soil. Yet this is just as likely as not; for when these insects have found their mates, the bliss of their lives is attained, and the short remaining term of their existence may be spent in fluttering up and down within a few hundred yards or so of space during the hours of sunlight, and in the neighbourhood of the nearest young cabbage plants. Assuming, then, that this is how the kindness we have shown will be returned, what will happen next? Well, at the end of about a fortnight, the curiously sculptured shells of these tiny eggs will burst open,

FIG. 192.—Two of the butterfly's eggs—magnified.

and out of each will come a little caterpillar. The first duty of the baby caterpillar will be to dispose of the empty eggshell. This it satisfactorily performs by eating it. Rather a tough and indigestible meal it may seem for an insect so young; however, this meal may be but the incentive that urges it to the juicy cabbage leaves—which it takes as a kind of dessert after the eggshell course. At all events, when the eggshell has been disposed of, it commences immediately upon its green food, without even moving from the spot on which it appeared.

As the other eggs were deposited at the same time, and have been subjected to exactly the same atmospheric conditions, they generally hatch out their larvæ more or less together. Consequently, as each caterpillar follows out almost identical tactics, we find the little party of baby caterpillars quietly feeding together on the under side of the leaf on which the mother insect so carefully placed the group of eggs; and the larvæ retain this habit of feeding together at least until they are half grown, and sometimes longer. In fact, so particular are they as regards this gregarious habit that they spin a silken tent-like covering under which they feed. Probably this serves to keep them together, and to protect them in some measure from certain minute winged parasitic foes that are particularly attentive towards them. The parasites deposit their eggs in the bodies of these larvæ, so that their offspring may thrive at the expense of the caterpillar host.

At the end of a week, or thereabouts, the young caterpillars all moult their skins; for the skins of caterpillars do not stretch, like those of most animals, as they grow. The shrunken skins are left in the old camp, and this is then deserted (Fig. 193). The larvæ, though, still remain in company, and a new camp is formed; but later, as their claspers become stronger, the camp is more or less dispensed with. Of course, as they increase in size "somebody's" cabbage plant suffers accordingly.

The larvæ feed together until they are nearly full-fed (Fig. 194), and then their bodies are conspicuously striped

with yellow and dotted with black spots or warts, a bristly hair arising from each of the latter. Such black and yellow combinations of colour are found in many insects in their various stages, and are instinctively recognized amongst

FIG. 193.—The shrunken skins of the young caterpillars are left in the old camp, and this is then deserted.

animals as associated with distasteful properties. Looking at the matter from this point of view, it becomes obvious how the gregarious feeding habit of these larvæ must benefit them; the greater the dispiay of their "warning colours" the more readily will their enemies be warned off.

But while this gathering of forces may protect the larvæ, what about "somebody's" cabbage? If the caterpillars have grown to maturity on that plant, even though they be but a small party, "somebody's" best course is to cut that plant and

FIG. 194.—The larvæ feed together until they are nearly full grown.

carry it and its trespassers carefully to the garden fire, for it will be eaten to the appearance of lacework, as everybody who has a garden well knows. There is, however, one advantage about this gregarious feeding, namely, that it confines the attention of the enemy to one plant; the next one in the row

may be quite untouched. Also, "somebody" should remember that by killing one of these female butterflies early in the summer, he prevents large numbers of caterpillars appearing later in the season. It is true it may appear a cruel act to kill so beautiful a creature, destructive though it may be, yet it is not nearly so cruel as killing innumerable caterpillars (which have to be diligently picked from the plants) later on.

My purpose here, though, is not to give a lesson on gardening, although this insect is, doubtless, one of the worst foes that the gardener has to contend with, but rather to give the details of the metamorphoses of this common insect, so that my reader may know just how it came to be. With that purpose I now proceed.

At the end of a month the caterpillars disperse, and each one then pursues its own path. Some ascend the garden wall until they reach the coping-stones at the top, the hollowed groove beneath these stones being a favourite hiding-place for the next stage in their development (Fig. 195). Here, then, the larva attaches itself by its tail-end, and again by a strong silken girdle round its central parts. Then it moults its last caterpillar skin, and when this is removed we have a chrysalis instead of a caterpillar. Other larvæ select the angles of wooden palings or similar situations; while others again prefer a branch, stem, or leaf to which to attach themselves.

FIG. 195.—Chrysalides of the butterfly removed from the groove beneath the coping-stones of a wall.

Two weeks later, or thereabouts, the chrysalis shell breaks open and a butterfly finds its way quickly into the sunlight. But this butterfly, if we saw it then, would be a "cripple"; its

wings would be wrapped round its body in a curious fashion, and in escaping from its chrysalis in the coping of the wall it is just possible that it might lose its foothold, and in which case it would fall to the ground. Afterwards it would rush about to find something up which it could climb while its wings developed—exactly like the example we first saw, as will be remembered.

Likewise as to the butterfly I referred to which one day found itself above the busy crowd in the Strand. This most probably came as a chrysalis on the basket that carried the cabbages to market, or it may have been attached to the stalk of one of the cabbages. Then in some quiet corner of the market it completed its development. Later, invited by the sunlight, it may have left the musty market for the open, and perhaps pursued its way through Southampton Street or Burleigh Street into the Strand. I suggest that its course lay through one of these side streets, as these insects usually fly rather low, and it would therefore most probably select such a route rather than over the tops of the tall buildings. But whether it would ever meet its mate, or find those flowers whose refreshing nectar it would need, would be doubtful in that locality.

As I have previously remarked, there may be several broods of these insects in one year during favourable weather. The caterpillars of the late autumn brood become chrysalides and remain as such throughout the winter ; and in their frail shell they are frozen and thawed perhaps many times, but at last wake up some day in May or June, and, bursting open their bonds, seek the sunlight, and become the parents of the first brood of butterflies for the new year.

CHAPTER XVIII

The Story of a Landscape during Twelve Months

The Scene depicted is Finham Bridge, near Stoneleigh, Warwickshire

JANUARY

A HEAVY snowstorm has covered the roads and fields with a mantle of white, which the rapid thaw is dissolving almost immediately, while the brown remnants of last year's vegetation are again asserting themselves on the river's banks. The branches of the trees look black and grim against the sky, and show no signs of returning life. The one cheering note of the scene is the music of the robin, which sings sweetly from the ivy cluster at the side of the bridge.

FEBRUARY

The scene has changed ; irregular patches of fresh green now begin to decorate the water's edge, but fields and trees remain very much the same as they appeared before the snowstorm, and a bleak, cold wind blows that ripples the water and makes the pedestrian hurry along.

MARCH

The water-current is not so swollen, and a delicate green tint enlivens the branches of the large willow tree at the back of the bridge, throwing into relief the dark-coloured branches of the alder in the foreground. Sunlight (the great engine which provides the motive power of all life) has commenced to play its part in the scene, and the little hawthorn bush that has been sheltered by the ivy clump and bridge throughout the winter months has been tempted to put forth some of its leaves, which shadow upon the bridge and remind us that the sun is really shining.

APRIL

The oak and elm trees down the road begin to show their young leaves and blot out some of the white sky, while the willow goes on increasing its show of delicate green. The cold winds, though, restrain the developing buds from responding too freely to the occasional bright glimpses of sunshine. The lark, however, cannot resist them, and with every one it soars aloft from the neighbouring meadow and makes its sweet music heard. The yellow stars of the lesser celandine and the pale mauve blossoms of the ladies' smock, together with the wide-eyed dandelions, brighten the river's banks.

MAY

THE ash tree (which is much later in leafing than the oak lower down the road), on the extreme left, has begun to put on its summer finery, and the alder has awakened to the fact that it is time to be up and doing. The flowers of the ladies' smock by the water's edge are continually visited by the handsome orange-tip butterfly, which sips their nectar and then ungratefully deposits its eggs beneath them—which, later on, means that hungry caterpillars will feed upon their seed-pods. The predominating music is the call of the cuckoo and the bleating of young lambs.

JUNE

The background of sky so conspicuous in January and February is now almost obliterated by the rapidly-developing leaves. In the foreground a fine plant of one of the wild kecks has developed and added beauty to the picture. The strong smell of the may-blossom pervades the atmosphere, and a busy hum from a daily-increasing host of insects produces a new kind of music. The nightingale (too impatient to wait until nightfall) occasionally indulges in some notes that startle us by their variety and sweetness.

JULY

The scene has now reached the height of its glory. The ash on the left and the alder in the foreground are now both in full leaf; the keck plant has thrown up its umbels of white flowers high above thc willow-herbs and grasses, and its blooms look handsome against the shadow in the stream. The hot and dusty road contrasts strongly with the coolness and shadow afforded in the precincts of the river. The music of the birds is comparatively quiet, but the humming of insects is greater than ever.

AUGUST

THE keck's flowers are over, and their stalks have turned brown while the seeds ripen. Rank nettles jostle with the water figwort, whose meat-coloured flowers the wasp is never tired of visiting. Minnows throw the surface of the water into tiny and pretty ripples as they dive to the centre of the stream when you approach. Tortoiseshell butterflies flitter by the roadside, while the humming of the bees is incessant as they move amongst the rich blooms of the sweetly-scented meadow-sweet. But the atmosphere seems heavy and languid, and the distant rumbling of thunder foretells an approaching storm.

SEPTEMBER

Much foliage has now more than completed its development, and many leaves are already showing their autumnal colours. Above the stream fluffy thistledown blows, and about its banks the mole has been busy throwing up many heaps of fine mould. The flowers by the water's edge have almost disappeared, strong clusters of nettles with tiny and unbeautiful green flowers predominate, and the few wasps that search amongst them for the late blooms of the water figwort seem sluggish, for the morning air is chilly for them.

OCTOBER

Red haws and hips now brighten the hedgerows where once the blooms of the may and wild rose were found. Leaves have become browned and shrivelled, and here and there an occasional one flutters to the ground, warning us that the trees from which they have fallen are preparing to meet the cold winter season. About the river hang hazy mists that lift suddenly when the sun appears, leaving the grasses on the banks and the spiders' snares amongst them bespangled with glistening drops of moisture. From the distance comes the cawing of noisy rooks, and near at hand a robin chirps sweetly.

NOVEMBER

In the photograph the landscape has now almost reproduced the May picture, but in reality it presents a very different appearance. In May a fresh, bright green enlivened trees and grasses, and everything was full of music and the joyousness of life ; now that cup of life is draining out its last dregs, while a mournful quietness reigns around, broken only occasionally by the strong wind that shakes the branches and showers down the brown leaves to thicken the leafy carpet that covers the ground. Heavy rains have swollen the stream, and near the water's edge deposits of clean sand mark the line to which the river reached the previous day. Strangely-coloured and weird-looking toadstools haunt the river's banks where once the celandine and dandelion showed their golden yellow ; but with all the changes that sweet musician, the robin, remains, giving a sparkling touch of life to a scene which, on the whole, is sad.

DECEMBER

Once again the bare branches stand out against the sky. The only green leaves now visible are those of the ivy clump, which during the leafy months seemed to sink into insignificance. Now, however, they have reasserted themselves; indeed, the richness of their green makes the ivy clump the bright and attractive centre of a landscape otherwise dull, for everything around looks cold and dead. Even the green of the grass has become so confused with brown stalks and fallen leaves that it has almost disappeared. The December sunlight has for a few moments smiled and cast weak shadows of the branches upon the bridge, which now are but rarely seen. The musical robin is absent, but two young male birds are vying with each other in praiseworthy emulation, though they yet have much to learn.

INDEX

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